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THE BEARING OF A SYNTHETIC DYE INDUSTRY UPON OUR NATIONAL WELFARE.*

BY

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INTRODUCTORY.

STATISTICS show that one out of every 1500 of our population is totally blind. The other 1499 of us are at least partially so. The one pathetic figure is doomed to complete his pilgrimage in utter darkness, forever excluded alike from the contemplation of what man has wrought through the centuries and from the enjoyment of all those matchless beauties of nature with which the Creator has so lavishly adorned this infinitesimal speck in His boundless universe. The other 1499 of us travel through life under the impression that we see everything around us. Yet are we blind in some one or in many important respects, for the layman is ever blind to the visions which open out before the imagination of the expert in any line of human endeavor. We cannot hope to see the picture with the eye of the artist, the building with the eye of the architect, or nature with the eye of the naturalist. In such matters, our blindness may be but partial or nearly total.

Thus the public still fail to see clearly the bearing of a well developed and diversified synthetic dye industry upon our individual and national welfare, and how vital it is to our progress

* Presented at the Stated Meeting of the Institute held Wednesday, February 16, 1921.

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and prosperity, or legislation would long ago have been enacted to protect and stimulate our domestic effort in this field and to safeguard it against threatened overwhelming by foreign dumping and competition.

To those who would raise the bogey of an American dye trust, I would reply that there is ample room in our country for small as well as large manufacturing units in this industry, as in the steel business for example. The existence of the U. S. Steel Corporation has not put the independent operators out of business, nor been to the disadvantage of the community.

But in world commerce, as in a world war, there is but one rational method of attack, and that is with an organization of a size and power commensurate with the undertaking. To attempt otherwise, will be as futile and as disastrous as were the efforts of the allies to fight the German war machine with a number of separate and insufficiently coördinated armies. The greatest and most powerful of Germany's industrial combinations is her giant dye combination. This huge consolidation has already called for additional capital, the life of the trust has been extended from the year 1966 to 2000, and its dissolution made more difficult by requiring a four-fifths, instead of a two-thirds, majority vote of the participating firms to unscramble it. Further, the Haber nitrogen fixation industry, with an authorized capitalization of half a billion marks, has been placed under the jurisdiction of this same dye trust. Control of the nitrogen supply means direct control of all explosives and of one of the most important constituents of all fertilizers, as well as indirect domination of many other industries. To compete in the world's markets with this giant organization, with the largest and finest equipment in the world, as the result of 40 years of intensive effort by thousands of eminent chemists and engineers, certain of our legislators appear to advocate a policy which will make it impossible for us to form any combination equal to the struggle. We have far less to fear from any American combination, the regulation of which is after all in our own hands, than from foreign domination of our industries, a control which Germany is now seeking to acquire, and toward which goal she is driving with characteristic thoroughness, persistence and concentration. Our grave danger lies in our failure to apprehend the deadly character of this menace to our safety, and in the short-sighted opposition of those textile manu-

facturers who cannot see that it is to their own selfish advantage to foster and encourage an American dye industry. If Germany once gains the upper hand in this key industry, we shall ultimately become a subject nation for, as Lincoln said, "no nation can long exist half slave and half free."

A FEW ILLUSTRATIONS.

What then is this synthetic dye industry that it is of such peculiar importance? Aside from the familiar uses of dyes themselves for coloring our flags, uniforms, clothing, and other fabrics, leather, paper, feathers, wood, and many other materials, are there other directions in which this industry ministers to the welfare of mankind and the progress of civilization? Let us look into the matter somewhat more closely, to find the answer to this question, and incidentally to gain a better appreciation of what it really covers.

When textiles, for example, are treated with solutions of certain chemicals, the fiber is permeated and penetrated and a more or less brilliant color imparted to it. The fabric so colored is said to be "dyed," and the material producing this effect is therefore known as a "dye" or "dyestuff." If the dyeing has been carried out properly, the fabric will be colored evenly throughout, and it will be impossible to remove the color by washing or by other solvents.

Painting, on the other hand, is merely a superficial coating of an article with a colored substance, termed a "pigment," suspended in a suitable liquid "vehicle." Almost any colored substance may serve as a pigment, and various dyes which combine with mineral salts to highly colored solids, called "lakes," are extensively used for this purpose, in addition to the more common mineral pigments not lakes. The usual vehicle for paints is linseed oil, since this on drying gives a tough weather-proof skin, retaining the pigment as an even coating.

Many of these dyes and lakes also form the basis of inks and ink powders.

Dyes are often divided into natural and artificial. The dyes of our ancestors were all natural products, and the proposal to manufacture artificial dyes was received with amusement and scorn, as though man-made products could ever hope to displace nature's greatest coloring agents, like madder and indigo. The

more pious of the community even referred to such undertakings as sacrilegious. Nevertheless, the chemist patiently continued his investigations and was soon able to show clearly that it was only certain constituents of the plants which possessed this tinctorial power and that the rest was either wholly useless or even objectionable. Then came the synthesis from anthracene of alizarin (in 1868), the active tinctorial constituent of madder, which was soon followed (in 1870) by the synthesis of indigo from benzole.

Chemistry has not only determined the actual tinctorial constituents in many natural dyes and reproduced them artificially, but it has also shown the way to prepare tens of thousands of other dyes which, so far as we are aware, are not found in nature. Compared with the industry of the artificial dyes, that of the natural dyes is to-day relatively insignificant. Long and patient study of the intimate chemical nature of these synthetic dyes has enabled the investigator to determine in most cases the particular combinations of atoms upon which this tinctorial power depends and the effect produced upon the shade by the alteration of these groups or the insertion of others, so that the expert can now tell in advance, if shown the molecular formula or structure of the dye, just what color it is likely to produce upon cloth. The chemist has succeeded in producing artificial dyes of every conceivable shade of the rainbow, at such a low price, of such purity, fastness and beauty, that the natural dyes either have been driven from the market, or the best of them (like alizarin and indigo) are now made synthetically. Logwood is the most important exception to this, although small amounts of gambier, turmeric, orchil, persian berry extract, saffron, madder and other natural dyes are still imported. The total value of the natural dyes imported in the year 1919 was $1,247,188, while the artificial dyes and color lakes made in this country the same year were worth $71,778,819.

Practically all of the artificial dyes are prepared synthetically, *i.e.*, built up step by step from simpler substances, somewhat as one might erect a house by laying a suitable foundation and then constructing the different stories upon it one at a time, and they are hence properly designated as " synthetic dyes," synthesis being the reverse of analysis.

This is simply and quickly demonstrated by the production of a dye from two colorless substances (Naphthol Orange); or, by heating together salicylic acid and wood alcohol, in presence of a

little sulfuric acid to assist the reaction, a wholly new compound results, identical with the main constituent of the natural oil of wintergreen and the one to which it owes its characteristic odor and taste, and which is therefore known as the synthetic oil of wintergreen. These are typical syntheses. To prove that natural oil of wintergreen really is a combination of the two substances stated, it can be heated with caustic soda solution, which treatment resolves it again into salicylic acid and wood alcohol. This is an analytical process; in this particular case called a "proximate" analysis, because each of the two substances obtained can be broken down into still simpler substances by suitable treatment.

The vast bulk of our synthetic dyes are all built up from five simple initial materials, the so-called "crudes," which are familiar to all of you. They are the following—benzole, toluene, naphthalene, anthracene and carbolic acid. Five others, less common but which yield a number of important dyes, are xylene, methyl anthracene, phenanthrene, cresylic acid and carbazole. As all of these ten crudes are found in the tar obtained when coal is heated for the production of illuminating gas or for the manufacture of coke, and as this material constitutes their chief source the resulting dyes are generally known as "coal tar dyes," and this appellation has been extended so as to be synonymous with "synthetic dyes," irrespective of whether actually made from coal tar or from crudes obtained from other sources.

These crudes then represent the foundations upon which we can build an endless variety of structures, of one or several stories. The building operations of the chemist differ somewhat from those of the contractor erecting a house, in that the chemist ordinarily puts up his structure one story at a time, each one being complete in itself, and it may be that he will run it up ten or fifteen stories before putting on the roof. At many of these intervening stages, it is entirely possible for him to change his mind and complete the building as a drug, a photographic developer, a perfume, or something else instead of a dye. These intermediate products therefore, standing as they do midway between the crude initial materials and finished products, are known conventionally as "intermediates," and from our ten crudes, approximately 300 intermediates are manufactured commercially for the production of the 1000 synthetic dyes now found in the world's markets.

According to the recent census conducted by the U. S. Tariff

Commission for the year 1919, there were 214 manufacturers of dyes and intermediates; 116 concerns engaged in the manufacture of intermediates, and 155 in the production of finished dyes and other synthetics, 90 of them turning out only dyes (63,402,194 pounds, valued at $67,598,855).

Those engaged in other lines than dyes were as follows:

Number of firms.	Goods mfd.	Pounds mfd.	Value of output.
34	Color lakes	7,569,921	$4,179,964
31	Medicinals	6,777,988	7,883,071
10	Photochemicals	335,509	1,059,340
9	Flavors	610,825	1,318,654
6	Phenolic resins (5) and tannins (1)	3,794,534	2,381,358
6	Perfumes	41,419	164,302

Considerable progress was recorded in the United States dye industry during 1919. The list of intermediates was augmented by 76 not previously manufactured here, bringing our total up to 216, and there was a considerable increase in the output of the higher grade ones. In the quality and quantity of finished dyes, there was also a gratifying growth as compared with 1918, the total production being 38 per cent. greater in amount than our total imports of dyes for the fiscal year 1914. In fact, we have ourselves already become exporters of dyes, our exports for the nine months ending September 30, 1920, having been valued at $26,032,389, which exceeds the total value of dyes imported during the fiscal year 1914. Of this amount $17,038,235 represented aniline dyes, $2,321,090 logwood extracts, and $6,673,064 other dyes. To be sure, an important factor in this achievement was the absence of foreign (especially German) competition, but it shows none the less the rapid strides made in the development of our domestic industry.[1]

Our 216 intermediates in 1919 were derived from the following crudes: benzole = 55, toluene = 47, xylene = 4, naphthalene = 66, anthracene = 10, carbolic acid = 26, other crudes = 8.

Perhaps it will help us to visualize the ramifications of this

[1] The dyes exported included sulphur dyes, mainly blacks and browns; direct cotton dyes, chiefly blacks, greens, blues and reds; acid dyes, especially scarlets and oranges; basic dyes, largely malachite green, methyl violet and magenta; and synthetic indigo. Obviously, a large export trade should be an important factor in enabling the manufacturer to supply the home consumer at a low price.

In addition to the 216 intermediates manufactured for commercial use, 119

industry more clearly if we alter our simile and liken our initial materials to a grove of trees, each one growing out of the mother earth of original sources (coal tar, for example), the branches and smaller twigs representing the intermediates and the fruit the final product, be it dye, drug, perfume or something else.

Let us step a little closer then and examine these trees somewhat more carefully, so as to ascertain the kind of soil upon which they grow, their relative size and spread, the nature and extent of this development, and the character of the fruit. In the brief time available, this examination must necessarily be hasty, superficial and incomplete, but it will at least give us a better idea than the hazy outline we have hitherto seen only from a considerable distance.

BENZENE (BENZOLE).

The first tree we come to is labelled Benzene, but is also called Benzole. Although benzene is the correct chemical designation, the name is unfortunate since there is a totally different compound, obtained from petroleum, which is known as "benzine," and this often leads to confusion. We shall therefore use the term benzole in what follows. In its size, development, and in the beauty and variety of its fruit, this benzole tree is one of the monarchs of the whole grove.[2]

The total production of all grades of benzole for the year 1919 is placed by experts at 63,000,000 gallons; of which about 53,000,000 gallons went for motor fuel; 5,500,000 gallons were produced in the form of pure benzole, and were consumed mainly by the dye industry; and 4,500,000 gallons were sold as 90 per

other intermediates and special organic chemicals were produced for research work. These totalled 2291 pounds and were valued at $23,333.

With the signing of the armistice, the production of intermediates and dyes used mainly for military purposes (explosives, toxic gases, dyes for uniforms, etc.) declined sharply. The intermediates most seriously affected were carbolic acid (referred to beyond), monochlorobenzene (80 per cent. drop), nitro naphthalene (36 per cent. drop), dimethylaniline (16.5 per cent. drop), diphenylamine and dinitro toluene among those used for explosives; and m-dinitrobenzene and m-nitraniline, manufactured for wool dyes (Alizarin Yellow GG and R) for army uniforms, and m-toluylene diamine for sulphur browns for cotton khaki uniforms.

[2] The output of benzole for the year 1918 was 52,240,758 gallons, valued at $14,627,743. This was obtained from the following sources: Tar distilleries, 3,015,848 gallons ($994,161); coke ovens, 44,804,900 gallons ($12,341,779); gas houses, 4,420,010 gallons ($1,281,803).

cent. benzole for use as solvent in the paint, rubber and other industries.[3]

Thus there appears to be an ample supply of benzole in our country to permit considerable expansion of our dye production, unless other industries requiring it in large amount very markedly enlarge their demands also. The question is an important one for the dye industry, as benzole is in many respects the most fundamental of all the crudes, all the rest of which, by the way, can be made from benzole in the organic laboratory, although not commercially.

The first branch which leaves the parent trunk of benzole, starts out under the name of nitrobenzole and, after one or two minor offshoots, continues as aniline, from which latter a most luxurious myriad growth springs. This nitrobenzole-aniline branch is not only the largest and most far-reaching of the entire tree, but it also has the most wonderful development and the most exuberant foliage.

Nitrobenzole is made direct from benzole by warming it with a mixture of nitric and sulfuric acids, the process being called nitration. The product is a pale yellow oil when freshly prepared, of a strong and rather rank bitter-almond odor; in fact, it was first used as a cheap perfume, under the name of oil or essence of mirbane, and small amounts are still occasionally used for that purpose. To a limited extent also it finds use in the manufacture of explosives. The great bulk of it, however, is so treated as to compel it to exchange the oxygen it contains for hydrogen, a process which the chemist terms reduction, and the nitrobenzole is thus reduced to aniline. This nitration and reduction for the manufacture of aniline are carried out mainly by the dye plants, since aniline is one of the most important of dye intermediates.[4]

[3] During the same year, we exported 76,592 barrels of coal tar, of an average net weight of 500 pounds per barrel, which would have yielded about 32,000 gallons more of benzole. As only 56.2 per cent. of our coke was produced in by-product ovens, large additional amounts are obtainable from this source by replacing all of the remaining wasteful beehive ovens by modern by-product ones. Increased amounts are also available from other sources whenever an enhanced price makes it an object.

[4] The nitrobenzole produced in the United States during 1919 amounted to 42,544,017 pounds, valued at $5,899,837, and in addition 21,513 pounds were imported. The aniline manufactured the same year amounted to 24,345,786 pounds, worth $5,932,536; and 1,446,909 pounds of aniline salts, sold for $359,296, besides which 21,273 pounds of these salts were imported (from England).

As the great majority of all the early coal tar dyes owed their origin, either directly or indirectly to aniline and very closely related compounds, the name Aniline Dyes has been widely current as synonymous with synthetic dyes, and still persists, although no longer appropriate except in restricted sense.

To give some idea of our 1919 production in the field of dyes derived from anilines, the following figures are cited:

	Pounds	Valued at
Indigo (including its sulpho acid)	10,563,494	$6,327,443
Nigrosine (both water- and alcohol-soluble)	2,006,316	1,232,965
Methyl Violet	574,436	1,403,179
Induline (both alcohol- and water-soluble)	566,905	318,727
Metanil Yellow	477,143	787,110
Methylene Blue	465,992	1,410,760
Bismarck Brown Y	412,574	417,276
Gallocyanine	365,243	1,105,346
Chrysoidine Y	314,581	326,223

It may surprise some of my hearers to learn that indigo is now generally manufactured from aniline, and that the amount of natural indigo imported is relatively negligible (46,878 pounds in the first six months of 1920). Indigo is probably the oldest dye known to man. It may be difficult to prove that the blue room in Noah's ark was decorated with it when he took his historic cruise, but it is scarcely to be doubted that Joseph's coat of many colors owed no small part of its brilliance to this common article, for indigo has been found in the pyramids of Egypt, in the ruined cities of Babylonia, and in the shops and houses of Pompeii. It is a product of many different plants, occurring in many countries, and has for untold ages been used by savage and civilized alike. And yet, at the present time, indigo is produced in commercially important quantities, from its natural source, in but two sections of the globe, the Bengal region of India, and Central America (Salvador). These are the last strongholds of an industry that was once world-wide. The chemist has succeeded in improving upon the leisurely and complicated processes of nature to such an extent that synthetic indigo is now produced rapidly and economically from aniline in any desired amount and of higher purity than the natural article. The indigo farmer, like the madder farmer and the cochineal raiser, will ultimately be compelled to

turn his land to other crops—possibly to the raising of much needed foodstuffs, in the case of India.

That the chemist can in a few minutes produce what the indigo plant requires a whole season to do, I will prove by making some indigo before your own eyes from a few simple chemicals. (Experiment.)

In our country, indigo ranks second to Sulphur Black in point of consumption, but it is first in world consumption on account of the large quantities used in China. Our production in 1919 exceeded our pre-war annual imports and our domestic needs, so that large amounts were exported. The du Pont Co. states that it can supply the entire requirements of the country from the output of its own plant.

The only dye rivalling indigo in the estimation of the ancients was Tyrian Purple, or the Purple of the Ancients, a dye so expensive that in the reign of Diocletian (300 A.D) one pound of purple wool cost about $240, which would make the dye itself worth approximately $5000 a pound. Its use became identified with royalty, and led to such expressions as "porphyrogenitism," "born to the purple," "royal purple," and the like. The dye was obtained from certain species of sea snails (Murex), which on decomposing formed this precious coloring material. It occurs in a small sac behind the head, and forms a drop of whitish liquid when first removed. On exposure to the air and light, it changes first to green, then blue, and finally purple. If set by an alkali (soap), it becomes a fast crimson, such as ecclesiastical dignitaries still wear. Great heaps of these snail shells are still to be found outside the ancient coast cities of the Mediterranean. After the fall of Tyre, the secret of the source of this dye appears to have been lost for centuries. In 1909, Professor Friedlaender gathered 12,000 of these mollusks and by very careful work succeeded in getting a total of 1.5 grams of the coloring material, which he investigated carefully and found to be identical with a dye prepared five years previously by Sachs, but not put upon the market because of its inferiority to others already available. The interesting thing about the nature of the dye is that it is a derivative of indigo, containing two bromine atoms in place of two of the hydrogens of ordinary indigo. It is now frequently made in the organic laboratories of our universities, and I have had several of my own students prepare it at various times.

It is perhaps worth noting in passing that aniline owes its name to its having been obtained first from indigo, the Arabic name of which was "anil," or "al-nil," that is "blue stuff," by distilling the latter with caustic soda, but it took chemists forty years to find out how to produce indigo from aniline.

In 1856, the late Sir William Perkin, while endeavoring to devise a method of preparing quinine synthetically, oxidized some commercial aniline oil, and obtained instead a purplish dye, which he called "mauve," and which was the first of the modern synthetic dyes. Perkin was quick to recognize the importance of his discovery, and this became the starting point for the wonderful synthetic dye industry and the origin of the name "aniline dyes." Perhaps you would like to see this historic experiment repeated. (Experiment.)

In the case of many of the dyes described beyond as prepared from naphthalene, carbolic acid, etc., an aniline derivative is often present as one of the components of the initial mixture. Certain of the aniline dyes, in the form of lakes, are employed as pigments, as already mentioned, and a considerable tonnage of such lakes is manufactured for this purpose; others form the basis of inks and ink powders.

A further and very important use for some of these dyes is as bacterial stains, in the diagnosis of various diseases; and occasionally they are used direct as bactericides in attacking sundry ailments.

But dyes are not the only fruit we find this aniline branch bearing. If we follow out certain lateral branches from it, we shall come upon products which are even more important, the synthetic drugs, upon which our health and even our lives may depend in times of critical illness. Among these you will find such well-known medicinals as acetanilide (antifebrine),[5] antipyrine, arsphenamine (salvarsan), neo-arsphenamine (neo-salvarsan), cinchophen (atophan), and many others.

The history of synthetic dyes is being repeated in the case of synthetic drugs. As we are all aware, the market during the past decade has been flooded by what are dubbed the "newer remedies," most of them derived from coal-tar dye intermediates, and practi-

[5] Our production of U. S. P. acetanilide in 1919 was 918,795 pounds, valued at $440,066.

cally all of them produced in the organic laboratory, where they were built up for the sole object of obtaining certain definite physiological results. They represent the efforts of the chemist to develop a really scientific materia medica, and the slow but sure progress in this direction is not only highly interesting, but means much to suffering humanity.

It was early recognized that the physiological action of various plants was due to certain definite chemical compounds which they happened to contain, and the first task of the chemist was to isolate, identify and study these "active principles." This study led quite naturally to attempts to reproduce artificially either these substances themselves or others of analogous structure, and to determine the particular atomic complexes responsible for the physiological effects observed. Then taking the knowledge thus gained, the chemist cut loose entirely from natural products and set about building up in his own laboratory new bodies which should contain these physiologically potent groups, and his activities in this direction are reflected in the innumerable new drugs constantly appearing. A steadily brightening light is being shed upon the connection between chemical structure and physiological action, and the physician now has at his command powerful healing drugs, which, so far as we know, are not duplicated in nature.

The natural substances are built up in the plant to play a definite rôle in the structure and life of those organisms, and the fact that they happen to be of therapeutic value when taken into the human system is purely fortuitous. The synthetic remedies, on the other hand, are synthesized with the specific object in view of producing substances which shall contain physiologically active groups, or so to modify a compound as to enhance its therapeutic value. It is not necessary, therefore, to construct the entire complicated molecule of an alkaloid if the same results can be secured with simpler structures, and this has been demonstrated already in many instances. In the case of the natural remedies again, other substances are frequently present which exert undesirable and even dangerous side effects. The great advantage of the synthetic drug then lies in its being a pure chemical individual, instead of a mixture of varying and uncertain content. This permits exact determination of its physiological action, accurate dosage, easy detection of adulteration and greater stability.

The life functions are essentially chemical, the cell being the

laboratory, and the isolation and chemical identification of the substances formed by the organism in its endeavor to protect itself against the inroads of different diseases should show to the chemist the type of compound to be added in order to support and stimulate this action. After the drug leaves the hands of the organic chemist, it is the task of the physiological chemist to ascertain just what happens to it in its course through the system, and to discover if possible which one of its numerous transformation products or ions is really the one upon which its therapeutic value depends. The time is surely coming when it will be necessary only for the physician to state just what effects he wishes to produce, and the chemist can build up for him a compound which will do all that is required and be free from unpleasant side or after effects, much as the child would build up a new kind of house with the same old blocks. This probably seems to you an extravagantly optimistic view, but if you will consider for a moment what has already been accomplished in this direction I am sure that you will share my enthusiasm. It takes years to solve such problems, of course—von Baeyer worked twenty years upon the molecular structure of indigo, but he finally solved the mystery.

The popular superstition that the medicinal value of a pure chemical compound is modified in some obscure but positive manner by the source from which it is derived, is as old as the hills. The famous "English drops," a drug which really consisted of nothing but ammonium carbonate with a little ethereal oil, sold for high prices up to the close of the 17th century, because it was stated by some that the ammonium it contained was obtained by the dry distillation of silk, while others even went so far as to maintain that it was prepared by distilling five pounds of the skulls of persons who had been hanged (or who had come to some other unnatural end) with two pounds of dried vipers, hartshorn and ivory. We smile, and yet this same kind of superstition still retains its hold upon the community and has materially retarded the introduction of really valuable synthetic remedies.

In addition to drugs and dyes, some of our important photographic developers owe their origin to nitrobenzole and aniline. Such are hydroquinone and metol,[6] for example; and at the outset of our participation in the war, the shortage of metol was felt

[6] Our 1919 production of hydroquinone was 272,329 pounds, valued at $552,087; and of metol, 59,024 pounds, valued at $508,434.

seriously, for there is little use in having photographs made of the enemy's lines from airplanes or captive balloons, unless suitable chemicals are available to develop and fix the picture.

Among the more fragrant blossoms of the benzole tree are the synthetic perfumes. These include one of the constituents of rose perfume (phenyl ethyl alcohol), which is present also in the odor of the orange blossom, one of powerful rose-leaf aroma, some of geranium-leaf (diphenyl oxide) and of syringa-like (acetophenone and methyl acetophenone) odors, and many others of delightful fragrance.

The same tree that bears these beautiful products bears also some of the deadly toxics used in the late war; such, for example, as the famous " sneeze gas " (diphenylchlorarsine) with which the Germans filled their blue cross shells, and which killed many of the allied soldiers when it was first employed, for the older allied masks did not give complete protection against it.

Other dangerous products are the various explosives derived from benzole, such as the more highly nitrated benzoles, T. N. A. (tetranitroaniline), Tetryl (tetranitromethylaniline), and picric acid. It is interesting to observe that the latter is really growing on a graft from the carbolic acid tree.

Aniline provides also one of the best stabilizers (diphenylamine) to protect smokeless propellants against deterioration, and yet this substance itself becomes a powerful explosive when sufficiently nitrated, or it may, on the other hand, be converted into some very beautiful dyes.

Like carbolic acid, aniline will unite with formaldehyde to a resinoid. The properties of the product are not such as to make it of any commercial service, but the reaction is such a simple one to carry out that we can do it here on this table. (Experiment.)

Even these manifold uses of aniline and other benzole derivatives do not begin to exhaust the list. Aniline and divers compounds produced therefrom find application also as accellerators in the vulcanization of rubber (*e.g.* thiocarbanilide, m-phenylene diamine, nitrosodimethylaniline), and yet further uses might be cited before the story was complete.[7]

[7] Other important benzole intermediates which should be mentioned are the following: m-dinitrobenzole, m- and p-nitraniline; the chloro and bromo benzoles, used during the war for the manufacture of carbolic and picric acids, for

TOLUENE (TOLUOLE).

Having examined the benzole tree somewhat critically, let us turn to the next tree in our coal-tar grove. The label on it reads "Toluene, or Toluole," and it is the next older brother to benzole, belonging in the same family and having all the family traits and characteristics, plus a few peculiarities of its own. In size and development it is almost as imposing as benzole.

As toluene is the raw material for the manufacture of the important explosive T. N. T., every effort was made during the war to increase our output of this crude by installing additional by-product coke ovens and by "stripping" illuminating gas, as well as by other processes, with the result that for the calendar year 1918 our total output was over 12,000,000 gallons, valued at over $18,000,000.[8] With the cessation of the war the demand and price fell precipitately, the production of pure toluene for 1919 being estimated at about 1,000,000 gallons, practically all of which went to the manufacturers of dyes, dye intermediates and medicinals.

Let us consider briefly some of the intermediates and final products which owe their origin to this crude.

As in the case of benzole, our toluene can be nitrated, giving nitro toluenes, which on reduction yield compounds (toluidines) similar in properties, utilization and possibilities to aniline. The nitration products include the T. N. T. noted above, other explosives, and one of the best of the synthetic musks, of powerful musk-like odor but, so far as we now know, not identical with the odoriferous constituent of the real musk from the musk deer. The toluidines yield dyes, drugs, etc., much in the same manner as

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dinitrophenol, and the parazole explosives; the sulpho benzoles, for carbolic acid and resorcinol and their derivatives.

Our 1919 production of some of these was:

	Pounds	Valued at
Monochlorobenzole	4,116,666	$623,875
Dimethylaniline	3,559,654	1,941,152
m-Dinitrobenzole	2,280,282	548,302
Thiocarbanilide	2,268,375	802,575
p-Nitraniline (and sulphate)	1,310,658	1,388,627
Benzidine base	1,084,922	1,370,393
Sulphanilic acid	1,023,861	243,656

[8] The 1918 production totalled 12,321,017 gallons, of a value of $18,255,978; divided as follows: Tar distillers, 1,596,353 gallons ($3,044,890); coke ovens, 8,861,948 gallons ($12,709,460); gas houses, 1,862,716 gallons ($2,501,628).

aniline, but having already followed out such a branch in the case of benzole, let us take a different one here—one inscribed "Chlorotoluenes."

When toluene is treated with chlorine, under proper conditions, some of the hydrogen it contains is driven out and the chlorine takes its place, new compounds being formed.

One of these (benzyl chloride; 1919 production 720,953 pounds, worth $166,182) is used for the manufacture of dyes known as Benzyl Violets, and is also the source of one of the most potent lachrymatory gases of the war (brombenzyl cyanide), which was prepared by acting upon it first with cyanide of potassium and then subjecting the product so obtained to the bromine extracted from the brine wells of Michigan or of the Ohio River valley. Strange as it may seem, if instead of using bromine we carry this intermediate product through a different series of reactions, the result is a wonderfully fragrant perfume possessing in high degree the delicious scent of the hyacinth and narcissus, and entirely free from any lachrymatory effect.

Another one of our chlorination products from toluene (benzal chloride), when boiled with lime gives the chief constituent of the oil of bitter almonds (benzaldehyde), which is better than the natural product in certain respects and is used as a substitute for it (1919 production of benzaldehyde, 518,634 pounds, valued at $403,109). From this synthetic oil of bitter almonds, many compounds are prepared which contribute to the happiness of our people. One of these is the popular dye called Malachite Green, of which we made 560,301 pounds in 1919, valued at $1,827,474. Another is synthetic oil of cinnamon, identical with the substance present in the natural oils of cinnamon and cassia, and to which they owe their characteristic odor and taste. It is consequently sold as a substitute for the natural article, and the value of the natural oil is decided commercially by the percentage of this substance present. Other products obtained from synthetic oil of bitter almonds include certain of the perfume substances actually present in orange blossoms, jasmine, tuberose, gardenia and ylang ylang, as well as purely artificial compounds of the odor of moss roses, of hyacinths and of narcissus.

When boiled with a strong solution of caustic potash, our oil of bitter almonds changes to two other bodies. One of these is benzoic acid, of which I shall have more to say in a moment. The

other is a mobile colorless liquid, related chemically to ordinary alcohol, and which is itself the source of drugs and perfumes. These two products can be made to unite to a totally different one (benzyl benzoate), which is a heavy oily liquid and which has the valuable property, when added to the "dope" or varnish for airplane wings, of causing this coating to dry slowly and harden without cracking, and it is hence called a " restrainer."

Whereas, as just described, one of the products obtained by the action of chlorine upon toluene yields oil of bitter almonds when boiled with lime, there is a third one of these chlorination products (benzo trichloride) which when treated in the same way gives benzoic acid instead, and this is one of the chief commercial methods for the manufacture of this important compound (1919 production, 699,108 pounds = $534,832). The synthetic product is identical with that obtained from storax, balsams of Peru or Tolu (whence the name toluene), or from other natural sources. It finds employment as a food preservative (in the form of its sodium salt), and in the manufacture of dyes and perfumes, as well as for the production of such drugs as procaine (novocaine),[9] anesthesine, barbital (veronal), chloramine-T and dichloramine-T.

Another branch from our toluene tree is marked " Sulpho derivatives," and it bears that remarkable sweetening principle, " Saccharin," four pounds of which will sweeten as much coffee as a ton of ordinary sugar. It is the sweetener customarily used by those people suffering from diseases which would be aggravated by cane sugar.

The 1919 production of toluene intermediates comprises the following as the larger items:

	Pounds	Valued at
o-Nitrotoluene	1,360,599	$312,416
p-Nitrotoluene	1,263,056	704,750
o-Toluidine	1,002,982	503,020
p-Toluidine	575,841	600,267
Dinitrotoluene	746,266	264,388
m-Toluylene diamine	493,544	504,063

The toluene dye manufactured in largest amount appears to have been Bismarck Brown 2R, of which we turned out 631,308 pounds, worth $659,332.

XYLENE (XYLOLE).

Standing next to benzole and toluene, and members of the same family, is a group of triplets, the three xylenes, whose first names

[9] In 1919 we produced 3448 pounds of procaine, valued at $330,334.

are Ortho, Meta and Para. Like other triplets, they are so fond of one another that it is not easy to separate them, and as they are so much alike in appearance and general behavior this is not necessary in many cases. They are found in that fraction of coal tar sold under the name of " solvent naphtha " which, as its name suggests, finds its major use in industry as a solvent.

Although the source of many beautiful dyes, and of other useful products, and possessing still greater possibilities than either benzole or toluene, the xylenes, largely because of the difficulty of separating them, have not achieved anything like the same development, and we will not tarry longer to examine them more closely.

NAPHTHALENE.

Turning now from the benzene family, we see another huge tree of widespreading habit and massive trunk, but of somewhat different appearance. Its tag reads " Naphthalene." It is brilliant with a fruitage of dyes of every conceivable shade, with only here and there a drug, perfume, or explosive.[10]

It is worth noting that we use this crude, in the form of moth balls, to protect against insect ravages textiles which may be dyed with naphthalene dyes.

Not many years ago, naphthalene was the starting point for the manufacture of synthetic indigo, but it is now more economical to use aniline for this purpose. One of the intermediate products in this older process, when combined with wood alcohol, is con-

[10] In 1918 we produced 40,138,092 pounds naphthalene from tar distilling operations, valued at $1,281,440; 16,087,498 pounds, worth $655,232, from by-product coke ovens; and 545,003 pounds, worth $15,497, from gas houses; or a total production of 56,770,593 pounds, valued at $1,952,169.

In 1919 the output fell to approximately 18,000,000 pounds, of which, roughly, two-thirds went to the manufacture of dyes, intermediates and related products, and the remainder chiefly to moth-balls.

At the termination of the war, considerable stocks of naphthalene had accumulated as by-product in our strenuous efforts to increase our supplies of toluene. Not only was less tar distilled in 1919, for reasons already cited, but the manufacturers fearing overproduction, in the tar that was distilled left more naphthalene in the creosote oil, so as to run up the yield of the latter, which was then in great demand. On removal of export restrictions, large orders for naphthalene dyes and intermediates suddenly made their appearance, causing an acute shortage of naphthalene in the latter part of 1919 and the early portion of 1920, and resulting in the importation of about 11,000,000 pounds in the first nine months of 1920.

verted into a perfume substance which is found in the flowers of the orange, jasmine, tuberose and narcissus.[11]

ANTHRACENE.

Another very important crude is Anthracene. Although as yet not the parent of such a numerous crop as either benzole, toluene or naphthalene, it is however the origin of some of the finest and fastest dyes in the world to-day, particularly in the class of vat dyes, a group to which by the way indigo belongs. The peculiarity of vat dyes is that on reduction they yield a soluble form of dye which thoroughly permeates and penetrates the fiber, and which on oxidation in the air separates the dye itself in an insoluble form within the fiber, extremely fast to light, washing and bleaching. As the operation is generally carried out by steeping the goods in a vat filled with the reduced dye, the process is termed vat dyeing.

[11] Among the intermediates requiring a specially expert technic, it is encouraging to find that in 1919 five firms successfully manufactured the so-called "gamma acid" (aminonaphthol sulpho acid, 2:8:6), their combined output amounting to 155,025 pounds, valued at $667,360. From this were synthesized 485,046 pounds of Oxamine Black BHN, worth $1,321,362, a most useful direct black, which can be developed on the fiber, as well as other valuable fast direct cotton dyes, and Zambesi Black, an important dye for union hosiery.

Among the naphthalene intermediates produced in 1919, the following are cited:

	Pounds	Valued at
Beta naphthol, tech.	4,835,778	$2,365,804
Aminonaphthol disulpho acid (H acid)	3,837,534	5,081,460
Nitronaphthalene	2,774,516	368,500
Naphthionic acid	2,008,189	1,235,742
Alpha naphthylamine	1,552,828	632,587
Naphthylamine trisulpho acid, 1:3:6:8	1,418,560	867,005
Naphthol disulpho acid, 2:3:6 (R acid)	1,008,007	721,341
Aminonaphthol sulpho acid, 1:2:4	837,384	808,894
Alpha naphthol	135,025	136,833
Beta naphthylamine, crude	99,597	167,590

Of the naphthalene dyes produced in large amounts during 1919, the following statistics are pertinent:

	Pounds	Valued at
Direct Deep Black EW	7,250,007	$7,521,343
Algama Black 10B	1,877,860	2,757,443
Benzo Blue 2B	1,380,335	1,386,291
Orange II	1,133,925	717,199
Congo Red	873,734	979,285
Salicine Black U	739,372	923,888
Eriochrome Black A	686,710	933,677
Ponceau 2R	552,680	439,515

Unfortunately, anthracene is one of the few really important crudes of which we still lack an adequate supply, and this is one reason why these dyes have been among the last to be manufactured here. In 1918, the actual anthracene contained in the crude product marketed was about 250,000 pounds, but very little of it was refined so as to make it available for the preparation of dyes, for which purpose it must be at least 80 per cent. pure. The output in 1919 was more than three times as much (813,318 pounds), and a large proportion of it was refined, but it is roughly estimated that had it all been refined there would have been only about one-fifth the amount required for our domestic market, assuming those needs to be in the neighborhood of 4,000,000 pounds pure anthracene per annum.

It is appropriate to point out that this situation is not due to any actual deficiency of anthracene as measured by the sum total present in our tar, nor to any grave technical obstacles to its recovery from a chemical or engineering standpoint, but is directly referable to the fact that its removal by the present method leaves the pitch so hard that it does not find a ready market here, and this makes the anthracene carry all the cost, and the dyes prepared from it would consequently be so expensive that they could not hope to compete with similar products from Germany or England, where hard pitch is readily salable for briquetting coal dust and coke breeze. The problem is one of the most important confronting our dye industry and is being vigorously attacked both by the tar distillers and by the organic chemist, the latter investigating the various methods by which anthraquinone, the most important of the anthracene intermediates, can be made from benzole and a naphthalene derivative (phthalic anhydride). Some success has already crowned efforts of the latter type, and one concern is already manufacturing this anthracene intermediate synthetically on a commercial scale.

When anthracene itself is available, this intermediate is easily produced by oxidation of the former. It is the mother-substance of such valuable classes of dyes as the alizarins (Turkey Red, etc.), indanthrenes, etc., which are of especial service in the dyeing of cotton shirtings, ginghams and calicoes.

The alizarin so prepared is the same as the alizarin obtained in years gone by from madder. This synthesis has already been alluded to, and it was the death knell of the madder industry. In

the ten years following this discovery, the output of natural alizarin fell from 500,000 tons per annum to less than 500, and this too in spite of attempted protective legislation on the part of the French Government, for the industry was largely a French one, decreeing that no trousers should be accepted for the French soldiers unless their brilliant red had been produced with natural madder.[12]

METHYL ANTHRACENE AND PHENANTHRENE.

These are relatively unimportant, since they are not yet obtainable in large amounts or at low prices.

Methyl anthracene bears the same relationship to anthracene that toluene does to benzole.

Phenanthrene belongs to a slightly different family, and is of interest also to the pharmaceutical chemist, as it is the mother-substance of the wonderful alkaloid morphine, as well as of certain other alkaloids, but as yet no method has been devised of building them up synthetically from this crude.

CARBOLIC ACID (PHENOL).

The foregoing six crudes belong to the class of compounds known as hydrocarbons, since they are all composed of but two elements, carbon and hydrogen, which are present in varying amounts and united in quite different ways. Carbolic acid, however, contains oxygen as well as carbon and hydrogen and, as its name indicates, possesses acid properties, while the hydrocarbons are neutral and indifferent bodies. Further, it is both a crude and an intermediate; a crude in that it can be separated from coal tar by distillation and purification; an intermediate in that it is prepared synthetically from benzole, as already stated. During the war, when the supply of toluene available was insufficient to provide all the T. N. T. required for bursting charges in shells, mines and torpedoes, recourse was had to picric acid, the raw material for which is carbolic acid. As the amount of carbolic obtained from coal tar was unequal to the task, huge plants were erected by the Government to manufacture it synthetically, the methods most widely employed consisting either in treating the benzole first with sulphuric acid and fusing the product with caustic soda or, when the

[12] In 1919 three firms turned out refined anthracene to an amount recorded above. The output of anthraquinone was 294,260 pounds, valued at $547,787.

supply of sulphuric acid also threatened to give out, by chlorinating the benzole first, then nitrating, boiling this product with lime and finally nitrating again. The result of establishing these great plants was an output in 1918 of 106,794,277 pounds of carbolic acid and when the war demand ceased and these plants were closed, a surplus stock of about 35,000,000 pounds was left on the Government's hands. This surplus hanging over the market forced the production for 1919 down to 1,543,659 pounds, and meant a drop in the total value of annual output from $37,270,284 to $155,624.

Picric acid, by the way, is the basis of the English lyddite, and the French melinite powders. It is a strong yellow dye, and was used for this purpose centuries before its power as an explosive was discovered; in fact, it is the oldest of all artificial organic dyes. In 1711, Woulfe found that by the action of nitric acid upon indigo, a liquid was obtained which dyed silk yellow, and this product was later shown to be picric acid. It was not until 1871 that Sprengel called attention to the fact that picric acid could be detonated, but no application of this observation was made until Turpin, in 1886, proposed its use as a bursting charge for shells.

Chloropicrin, one of the deadly war gases used in considerable amounts by both sides in the recent war, is manufactured by boiling picric acid with bleaching powder in water solution.

The therapeutic properties of carbolic acid are familiar to all of us, and its extensive employment as a general disinfectant and antiseptic.

When carbolic acid is treated first to a dose of caustic soda and then chloroformed, it is transformed into two new substances; one of which is readily changed into a perfume with the odor of the blooming hawthorne and hence sold under the name of Aubepine, from the French name for the hawthorne. The other has a faint but pleasing odor, and occurs in the blossoms of the spirea (ulmaria). By coupling it with the acid found in vinegar (acetic acid), it forms the perfume substance called coumarin, the compound to which the odor of the woodruff and the sweet clover are due, and which is the odoriferous and gustiferous principle of the tonka beans. These latter are often mixed with vanilla beans, because of their vanilla-like flavor and aroma, in the preparation of the natural vanilla extracts, as they give to the extract a rather pleasanter bouquet. As the organic chemist can synthesize the important component of vanilla beans by starting with wood tar, it is entirely within his power to fabricate a high-grade vanilla

extract of fine bouquet, in which the alcohol has been made from limestone and coke, or possibly from sawdust, the vanilla from wood tar and the bouquet from coal tar. Coumarin is the basis also of most " new-mown hay " perfumes.

If, instead of chloroforming our carbolic acid after its caustic soda treatment, we bake it in presence of the gas which bubbles up in our soda water, the product is the familiar salicylic acid,[13] so extensively employed as a remedy, either in the form of the acid itself, its salts, or such derivatives as aspirin, salol, salophen, and the like, in cases of rheumatism, grippe, headaches and fevers, and also made use of as a food preservative and for the manufacture of many dyes. I have already shown you how we can combine this rheumatism acid with wood alcohol and produce the synthetic oil of wintergreen.

But let us vary once more the method of attack, and subject our carbolic acid to the action of dilute nitric acid. The result will again be two distinct and new products; one of which yields dyes and other derivatives of commercial value, while from the other one, the valuable drug phenacetin is manufactured.

Under the influence of a somewhat stronger nitric acid, carbolic acid yields an intermediate which may be converted on the one hand into picric acid, or on the other into Sulphur Black, a dye which is consumed in the United States in larger amounts than any other, over 14,500,000 pounds having been produced here in 1919 by 13 different manufacturers, and some of their brands being admittedly superior to the finest products imported from Germany prior to the war. With a still stronger nitric acid, assisted by some concentrated sulphuric acid, carbolic passes into picric acid, which has been discussed above.

The synthetic resins of the bakelite, condensite and redmanol type, are prepared from carbolic acid (or cresol) and formaldehyde (or closely related compounds). These synthetic resins have found a wide sphere of usefulness as substitutes for hard rubber, since they can be filled, molded, machined, etc., and have a high dielectric constant. Synthetic tannins of the neradol class are prepared from these same initial materials.

The mild laxative, phenolphthalein, is likewise a carbolic derivative.

[13] In 1919 the U. S. production of technical salicylic acid was 3,467,055 pounds, valued at $1,009,462, and of the U. S. P. grade, 2,619,726 pounds, worth $918,832.

CRESYLIC ACID (CRESOL).

Cresol, or cresylic acid, is another case of triplets, much like the xylenes, with the same first names, and bearing a relationship to carbolic acid similar to that of the xylenes to toluene.

These cresols are present in the creosote or dead oil from coal tar, the main use of which is for the preservation of wood (telegraph poles, fence posts, railroad ties, paving blocks, etc.), although some is employed also in the preparation of sheep dips, of lysol and of other emulsifiable disinfectants.

It is not an easy task to separate the three cresols from the crude material and obtain them pure, but when they are so isolated they are found to have much the same properties as carbolic acid and to be serviceable for similar purposes. Their non-availability is reflected in their limited use for synthetic purposes.

Carbolic and cresylic make up the bulk of what are termed the tar acids. The chief source is gas tar, for the tar from coke ovens contains but small amounts.[14]

CARBAZOLE.

This crude differs radically from the foregoing in that it is composed of carbon, hydrogen and nitrogen.

It occurs in coal tar associated with anthracene and is separated with it. An increased demand for carbazole would thus encourage manufacturers to refine their anthracene. In 1919, but one firm reported the commercial production of carbazole, although it is the raw material for a very valuable dye called Hydrone Blue.[15]

In what perhaps has seemed to you a rather long drawn out cataloguing of coal tar products, I would remind you that we have considered but five crudes in any detail, and even in these enumerated but a few of the many thousands of compounds to which they give rise, while over 150 other separate and distinct chemical individuals have been isolated from coal tar, each of which is the starting point of other long series of descendants; and coal tar is not the only source from which the dye industry derives its initial

[14] In 1919 our production of creosote oil was 43,434,059 gallons, valued at $4,264,594; and we imported 11,268,359 gallons additional, at a cost of $1,374,217. Purified cresol to the amount of 6,435,650 pounds was imported, at an expense of $557,214.

In 1918 o-cresol was manufactured commercially in this country, but no meta or para has been reported.

[15] During the 1920 fiscal year (July 1st to June 30th), we imported 21,593 pounds Hydrone Blue, at an invoice value of $8375.

materials. The Coal Tar grove is, therefore, both flourishing and extensive. The synthetic dye industry is primarily and chiefly responsible for its wonderful development and rich fruitage, and without the fostering care of that industry it will speedily languish and decay.

INFLUENCE UPON ADVANCEMENT OF CHEMISTRY.

The influence of the synthetic dye industry upon the advancement of the science of chemistry has been deep and far-reaching. For the solution of many of the problems arising in the plant, experts in all branches of chemistry must be enlisted, and the results of this concentrated and intensive investigation have led not only to the solution of the particular problem immediately in hand, but of many collateral problems as well, inorganic as well as organic, and not infrequently to the uncovering of new laws of fundamental significance to the entire science.

Great industrial research laboratories have been established and organized by the manufacturers, manned by able investigators and, in Germany for example, the university laboratories have often been called into active coöperation, thus adding the knowledge and experience of the university professor to that of the technical staffs of the plants on the one hand and, on the other, vitalizing the university teaching by bringing the teacher into actual personal contact with the applications of his lectures and keeping his information more nearly up to date. It is a pleasure to record that this coöperation has also taken the form of endowments in several instances, providing much needed financial assistance for our educational institutions, and giving to deserving students an opportunity otherwise unattainable of gaining advanced training and thus becoming more useful citizens.

For the highly trained synthetic organic chemist, the dye industry with its collateral and related industries makes the greatest demand. As the manufacture of explosives and of chemical warfare munitions is likewise mainly dependent upon men with similar education and experience, and much of the equipment and many of the operations are alike in all three lines of activity, it will be readily understood why a modern synthetic dye plant is referred to as "a potential arsenal." Germany's great dye plants were converted almost over night into real arsenals for the manufacture of munitions.

Badly handicapped as we were in the matter of dye plants when

we entered the war, our most serious deficiency was the lack of a sufficient number of skilled organic chemists to man new plants when these were ready. Under the stress of war conditions, a factory may be erected and equipped in six months, but it takes six years' education after high school to fit a man to begin learning the practical operations involved in large-scale production, and many months of such experience before he can really handle his job efficiently. It may be that a million men "will spring to arms over night," but the crop of chemists grows more slowly.

Following the armistice, large numbers of young men entered our universities filled with enthusiasm over the prospects of developing in our country a great dye industry, and eager to prepare themselves for a worthy part in that expected development. The attitude of Congress, in holding up for nearly two years the legislation necessary to protect and encourage this business, has chilled the enthusiasm of these students, and many are either in serious doubt as to the wisdom of embarking upon such a career, or have already switched to something else. A continuance of this attitude on the part of the Congress will result in an immediate and considerable reduction in the number of young men selecting organic chemistry as a profession, and should our country be forced into war in the near future, she will once more be wholly unprepared through absence of the experts necessary to increase her output of munitions, and the lack of officers for the industrial army is fully as serious as for the military army.

Of the 214 concerns engaged in the manufacture of dyes or intermediates in the calendar year, 1919, 65 maintained separate research laboratories for the investigation of problems arising in the works and for the discovery of new substances or improved processes. The amount of money spent on these laboratories that year for salaries, apparatus and supplies, deducting the salable products turned out by them, but without figuring any overhead or all the cost of translating test-tube results into successful large-scale operation, was $4,274,247.

WHAT WOULD THE LOSS OF THIS INDUSTRY MEAN TO US?

Let us understand fully what the curtailment or abandonment of this industry is likely to involve, for it is not so much the amount of money involved, although that is considerable, as it is the bearing upon our life as a nation that counts. Its immediate

consequences, some of which are making their appearance even now, may be briefly recapitulated as follows:

1. Thousands of unskilled laborers thrown out of employment.

2. Large numbers of specially trained technical experts forced to seek other means of livelihood, and the economic loss involved in scrapping the experience gained in the dye industry.

3. Abandonment by the manufacturers of all plans for development and expansion, and the closing of plants now in operation.

4. Fewer students for the courses in chemistry at our educational institutions.

5. Termination or reduction of research work, both in the laboratories of the industry and in coöperative investigations with educational institutions, with all that this implies in retardation of the development of our science at a time when the world is looking to us to take the leadership.

6. Inability of teachers of applied organic chemistry to give their students up-to-date information in the field of synthetic dyes, through loss of personal contact with the manufacturer, and an inevitable resulting dependence upon the ancient history of the average text-book of industrial chemistry.

7. Subjugation of our great textile industry, and of other industries using dyes or dye intermediates, by foreign manufacturers, and in the event of our being cut off from such supplies by another war, once again to be face to face with a famine, not only in the dyes needed for our flags, uniforms, and other articles, and the bacteriological stains for the diagnosis of disease, but in many indispensable drugs and in compounds of serious concern to the manufacturers of photographic chemicals, food preservatives, explosives, toxic gases and other war munitions, paints, inks, perfumes and flavoring principles, artificial resins, plastics, tannins, and accelerators for rubber vulcanization; the distilling of coal tar and the recovery of by-products from the coking of coal will also suffer from the loss of this market for their products.

8. Should we be one of the belligerents, there will be but few dye plants available for conversion to munition manufacturing (be it explosives, toxic gases, smokes, incendiaries, or what not), and no reserve of trained men to take charge of such operations. It is trite, but true, that modern military power is dependent upon industrial organization and efficiency.

9. Domination of our trade in dyes and dye intermediates, by

Germany for example, is quite certain to lead to the control of others of our industries as well, until the penetration of our industrial fibre will resemble that of the chestnut tree by the deadly fungus which has so nearly obliterated these beautiful trees from our groves.

10. The world markets open to other nations will be inaccessible to us.

It is no exaggeration to say that the life of the state, as of the individual, some day may be decided by the existence or non-existence here of a well-developed, expanding and progressive synthetic dye industry, and if this hasty and very imperfect presentation of the subject has helped to give you any better appreciation of its significance to all of us, I shall feel well repaid for the time spent in putting together these rather rambling remarks.

As chemical warfare was responsible for nearly a third of all our casualties in the war, and as this proportion is quite certain to be higher in future conflicts, it is idle to talk about disarmament without including the munition plants represented by Germany's great dye industry and nitrogen-fixation units. Because of the rôle which these play in the economic life of the nation at peace, they cannot be destroyed without destroying Germany as well. Where disarmament is impossible, there is but one answer—counterbalancing armament. Hence, the one sane and practicable disarmament which we can really accomplish is an offsetting equivalent or superior development of our own dye and air-nitrogen industries. It is the most effective guarantee of peace, and in the long run much the cheapest form of insurance.

The important question is "Do you want the synthetic dye industry to remain and develop in this country, or not?" If you do not, or are wholly indifferent, take no action whatever. The German propaganda and its friends will do the rest for you. But if you are convinced that this industry is linked in so vital and intimate a manner with the welfare of our citizens and the safety of our state that it is essential to the maintenance of our proud position among the nations of the world, you will do what you can to see to it that such legislation is promptly enacted as will provide adequate protection while the industry is still adolescent and vulnerable, and will immediately wire your senators and representatives in the Congress urging such action upon them, for "Where there is no vision, the people perish."

SOME OPERATING CHARACTERISTICS OF ELECTRON TUBES.*

BY

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THE three-element vacuum tube is becoming a fairly common tool to the physicist, electrical engineer and experimenter, and the literature on the subject has grown rapidly, so that at the present time it is really voluminous.

Its theory of operation is quite widely known and is found in most modern textbooks on physics and radio communication. Radio literature is usually generously sprinkled with vacuum-tube circuit diagrams.

It is not the purpose of this paper to take up any of the fundamental theories of operation of the tube or its circuits, but to furnish information and give help to those who professionally, or for pleasure, experiment with these devices.

It is also not the intention to attempt to cover the field of tube operation, but merely to call attention to certain phases of the subject not widely known or appreciated.

It is a rather usual occurrence to those working with vacuum tubes in an experimental way to encounter unlooked-for difficulties and obtain unexpected results.

A number of these more unusual effects will be discussed; first those of a general nature, next those occurring when the tube is used as an oscillator, and finally a few when the tube is used for a number of other purposes.

A tungsten filament type of tube is assumed in the paragraphs to follow, and most of the discussion relates to power tubes.

Certain properties of a tungsten filament as an electron emitting source will first be mentioned, for although these are simple and probably well known, they will bear repetition because of their importance in obtaining satisfactory results with such a type of tube.

* Presented at the Stated Meeting of the Institute held Wednesday, December 15, 1920.

The electron emission and life of a filament are quite sensitive to changes of filament current. A 1 per cent. change in filament current causes about a 25 per cent. change in life and approximately a 10 per cent. change in total electron emission. An increasing filament current decreases the life and increases the emission.

Owing to the fact that, like most other metals, tungsten has a positive temperature coefficient of resistance, a certain percentage change of current gives a correspondingly greater change of voltage. Numerically this amounts to a 1¾ per cent. change of voltage for a 1 per cent. change of current. Therefore life and electron emission from a tungsten filament are more subject to filament current change than voltage change of the filament.

Although in the past it has usually been the custom to operate the tungsten filaments of vacuum tubes at an approximately constant current by means of an ammeter, operation at constant voltage is to be recommended as giving a much longer life to the filament in about the ratio of three to one.

In operating tungsten filaments in vacuum tubes, observance of the three following rules will greatly increase the useful life of the tube:

(1) The most favorable adjustment of the set, of which the tube is a part, is the one which gives the desired result with the lowest value of plate current.

(2) The filament current or temperature should not be materially raised to give a slightly increased output or signal which is not vitally necessary.

(3) Do not, for any length of time, exceed the maximum filament rating, and in all cases reduce the filament temperature to as low a value as is consistent with satisfactory operation of the apparatus.

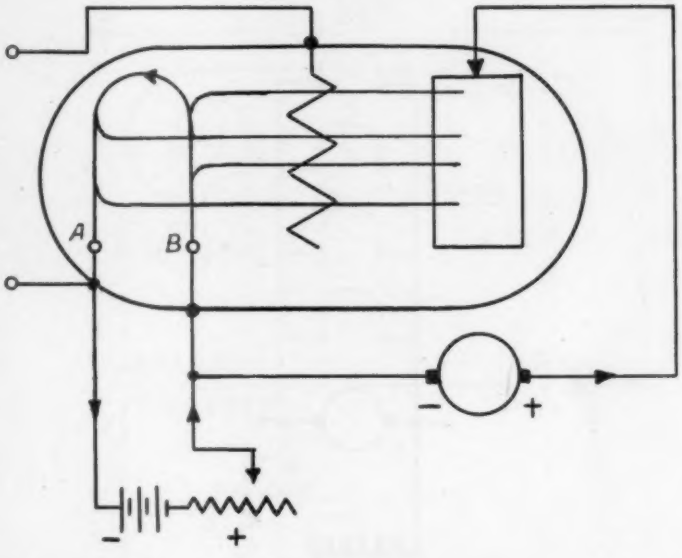
Most tubes are designed for operation in one or two designated positions: that is, vertically or horizontally, with a certain side or end up. It is advisable to observe this feature because a hot tungsten filament has a tendency to very slowly sag, and if this is not prevented or compensated by operation in a certain designated position, there is liable to be changes in the electrical constants of the tube, caused by changes in distance between the electrodes.

If for some reason the vacuum in a tube becomes faulty, it is usually noted by the characteristic glow due to ionization of the gases present. If gases evolved from the metal parts or glass,

due usually to the heat from an overload, are the cause of this glow, it will be blue in color; whereas, if it is due to leakage air, it will appear purple or pink.

Occasionally a tube will be met with which, when the filament is energized, shows a sort of yellowish-white smoke in the interior near the filament or it fails to come up to normal brilliancy at rated ampères and a dark-blue powder forms on the plate and grid.

FIG. 1.



Both these effects are due to considerable amounts of leakage air, but formed under different conditions.

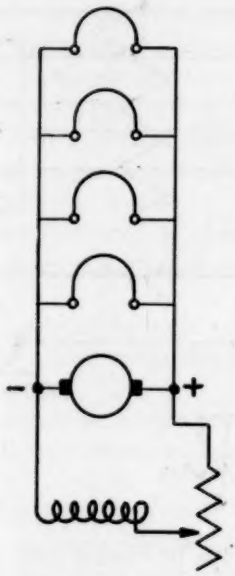
The smoke or powder formed is an oxide of tungsten which exists in several forms and varies in color from a very light yellow to a very dark blue, depending upon the conditions at the time of its formation.

One limit to the possible output of a tube as an oscillator is the amount of energy that can be dissipated safely in the form of heat. If it is attempted to dissipate too much energy, the glass and electrodes will be liable to evolve gas which reduces the vacuum. If the tube is enclosed in a small unventilated space, normal operation may overheat the glass of the bulb and cause it to evolve gas. This is most likely to occur where a number of tubes are

operated in parallel, thus causing a considerable energy dissipation in a small area.

When the filament of a power tube is operated from a direct current source through a regulating resistance, the plate current causes an inequality in the filament current. This action is represented in Fig. 1. The electron emission occurs along the length of the filament and therefore one end of the filament will carry more total current than the other end; this causes one end of the

FIG. 2.

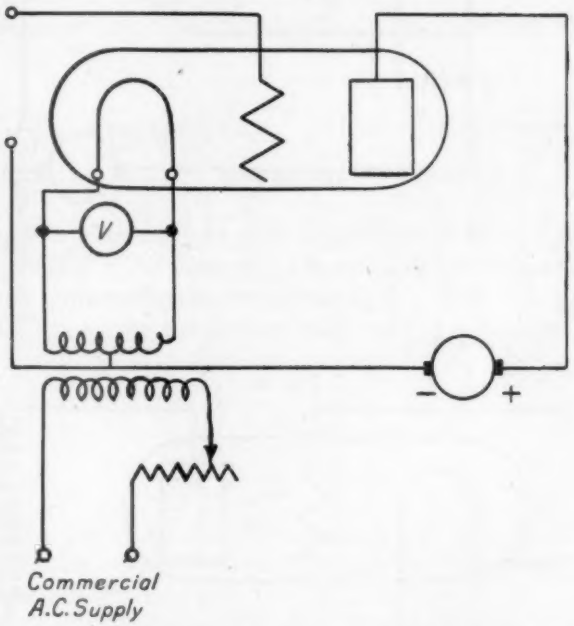


filament to be the hotter, which for the same amount of emission will shorten the life. The relative resistance values of the regulating rheostat and the filament, and also the location of the point of connection between the filament and plate circuits, determines the amount and direction of this effect. As shown in Fig. 1, the plate current causes the filament temperature to decrease at the positive filament terminal. This is the safest and best mode of connection.

If, however, the filament is operated from a few cells of storage battery or directly from a low-voltage direct-current generator so that the resistance in series with the filament is small,

it is immaterial whether the return from the plate circuit is made to the positive or negative terminal of the filament; the heating current in the negative side of the filament is increased by the same amount. A considerable resistance in series with the filament is essential to any alteration in the distribution of the flow of plate current through the filament circuit as a safety precaution. As the plate current is usually in the neighborhood of 2 per cent. to 7 per cent. of the filament current, and as a 3 per cent. increase of

FIG. 3.

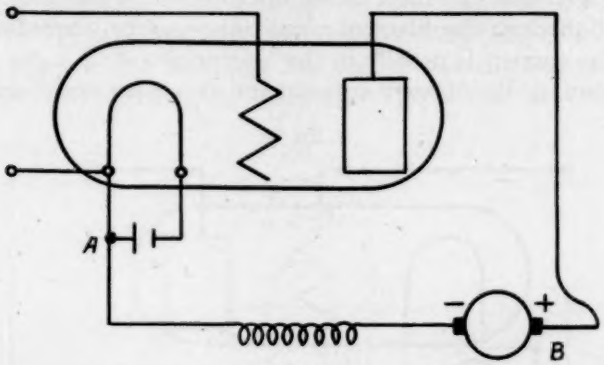


filament current halves the life of a tungsten filament, the importance of this effect is evident.

If a low-voltage direct-current generator is used for filament lighting, it is usually connected in circuit as shown in Fig. 2, the filaments being directly connected to the armature leads, the adjustment of filament temperature being made by a rheostat in the field circuit of the generator. With such an arrangement difficulty may be experienced with the generator not building up if the filaments are left in circuit. This is owing to the fact that the cold resistance of a tungsten filament is very low, only one-

thirteenth to one-sixteenth of its normal operating resistance. Therefore, if a small low-voltage direct-current generator is used at full load to supply tungsten filaments, the cold resistance of the

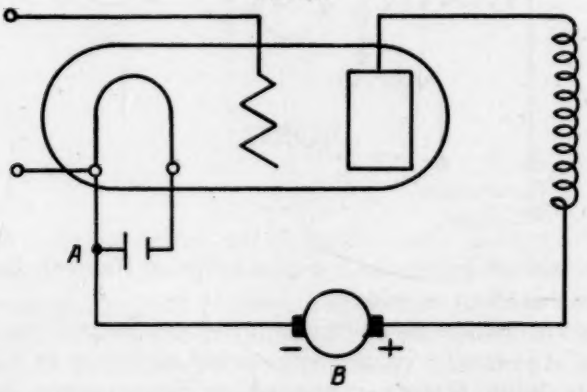
FIG. 4*a*.



filaments may be so low that it acts as practically a short circuit on the armature and prevents the generator from building up.

On power tubes it is preferable to use alternating current for filament excitation. The chief reason for using *A.C.* is that it

FIG. 4*b*.



obviates the unbalanced condition of a *D.C.* filament current, as described in a previous paragraph. It is also more practical to generate and distribute the low-voltage high-current energy for filament operation by means of *A.C.*

In using *A.C.* for filament excitation the filament terminals

should be connected directly to the transformer low-voltage terminals, the regulating resistance being placed on the power side. Also the return of the grid and plate circuit should be made to a centre tap of the coil supplying the filament. This mode of connection assures minimum disturbance in the plate and grid circuits from the frequency of the filament source. Both these points are shown in Fig. 3.

Some points in connection with the use of tubes as oscillators will next be taken up.

In the various diagrams of connections which are shown in this paper, each one is simplified so as to more clearly show the

FIG. 5*a*.

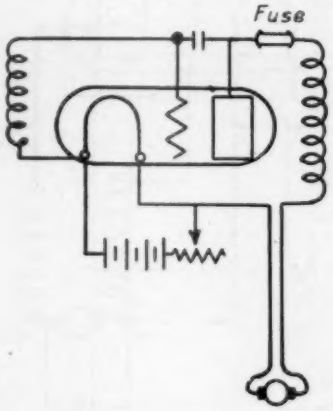
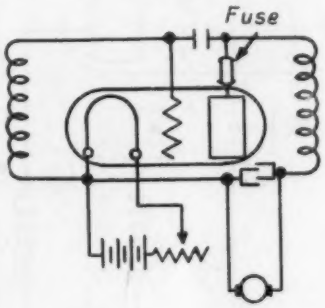


FIG. 5*b*.



point under discussion. For this reason many diagrams for clearness or simplicity omit features which in another paragraph are shown to be advisable.

In all tube oscillator circuits there is an inductance in the plate circuit across which the high-frequency voltage is set up. Care should be taken that this inductance is not placed between the filament energy source and the plate energy source, as shown in Fig. 4*a*. Both of these sources have usually a large capacity or a certain resistance to ground, so that a circulating current will flow through the coil and through each source to ground. For the type of circuit shown the correct arrangement is shown in Fig. 4*b*. The importance of having the circuit correct in this respect is greater the greater the power and the higher the voltage used.

In arranging an oscillating circuit to deliver high-frequency energy, it is important to reduce to a minimum the losses in the high-frequency circuits. Not only should the wires used be of low resistance and the condensers have low losses, but it is best to trace through the circuits carrying high-frequency currents to be sure that the resistance is a minimum.

Three common errors in this respect are shown in Fig. 5*a* which represents a capacity coupled oscillator circuit. In this diagram the high-frequency current of the oscillating circuit must pass through a resistance path comprising the filament in parallel

FIG. 6*a*.

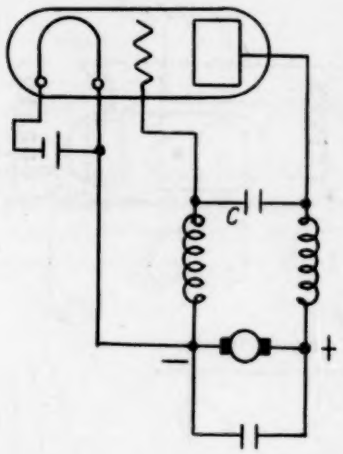
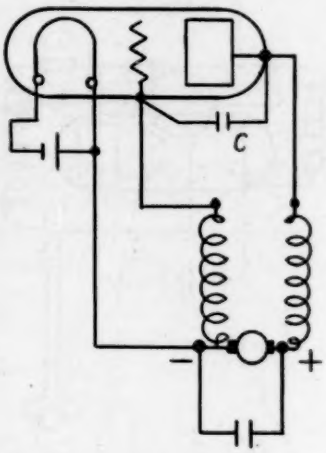


FIG. 6*b*.

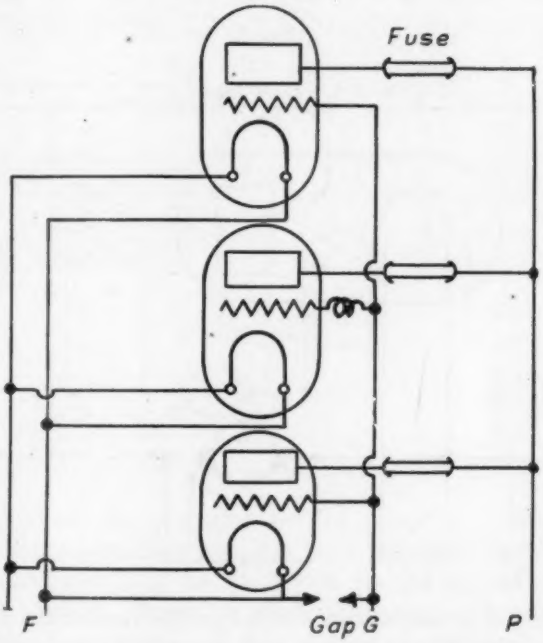


with its resistance and battery source. Also it must pass through a fuse in the plate circuit and through the plate voltage source. In Fig. 5*b* the same circuit is shown with these three errors corrected, the first, by changing the wiring so that the return of the grid and plate circuits is brought back to the same filament terminal; the second, by change of the fuse position, and the third, by shunting the plate circuit generator with a by-pass condenser.

For miscellaneous laboratory work the capacity coupled type of circuit is a very convenient one to set up and operate, usually giving little trouble. However, if the circuit happens to be set up in a certain peculiar way, very puzzling results and failure to operate may sometimes occur, particularly if a tube of low impedance is used or several tubes in parallel.

This arrangement is shown in Fig. 6*a*. If, as shown in this diagram, the leads from the coupling condenser *C* are connected to the plate and grid coil terminals rather than to the corresponding tube terminals, as shown in Fig. 6*b*, very high-frequency oscillations may occur, a second capacity coupled circuit being formed, the capacity between the electrodes acting as the coupling condenser and the leads between the grid and plate coils and the

FIG. 7.



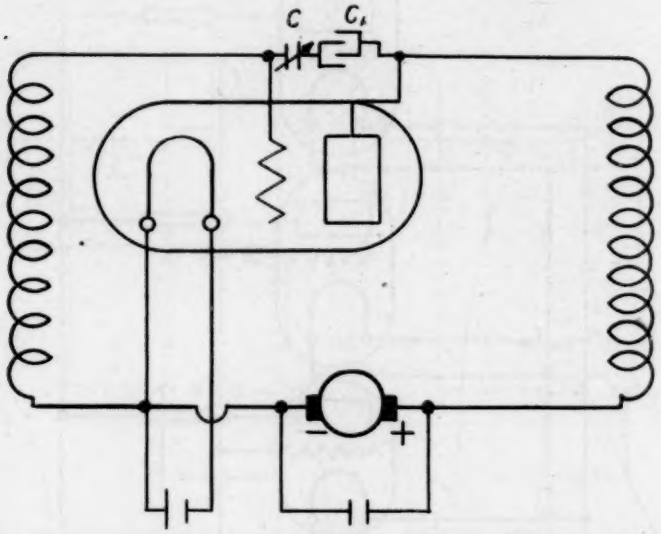
corresponding tube terminals acting as the grid and plate inductances. This condition is accentuated by having these leads long and the leads to the coupling capacity short.

This unexpected production of ultra high-frequency oscillations is often a very troublesome problem in high-power tube apparatus when a considerable number of tubes are operated in parallel. The low impedance of the tubes in parallel accentuates the effect. One expedient which often aids in overcoming this difficulty is the insertion of a very small inductance (a few microhenries) in one or more of the grid leads close to a tube grid terminal.

This coil is shown in Fig. 7. This figure also shows fuses in the plate circuit of each individual tube, a very desirable feature on high-power high-voltage tubes. This fuse should blow at two to four times the rated plate current of the tube.

This Fig. 7 also shows another desirable feature for high-voltage power-tube circuits. In experimental work with oscillating circuits unusual conditions may occur which will cause transient voltages to be set up between the grid and filament which will reach peak values many times higher than that set up in normal

FIG. 8.



operation. It is impractical to design and construct a tube and its base to stand up under this very abnormal voltage, which only occasionally occurs, due to incorrect adjustment.

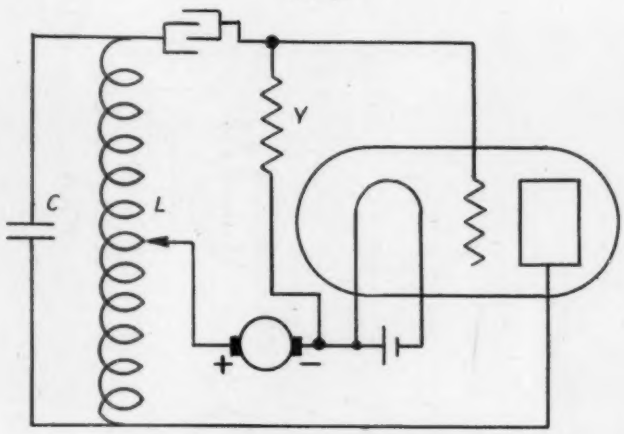
A safety spark gap should therefore be provided between the grid and filament terminals at or near the tube socket or mounting. This gap should be adjusted to between one-thirty-second and one-quarter inch, depending upon the plate voltage employed and the number and type of tubes used. This precaution should be taken on any tube or group of tubes delivering over 50 watts of alternating current energy or operating at a plate potential above 2000 volts.

In one of the simplest and most frequently used forms of

capacity coupled circuit there is a precaution that should be observed.

This is illustrated in Fig. 8. It will be noted that the coupling capacity C has one of its terminals connected through the grid coil to the negative terminal of the high-voltage plate source, while the other side of this capacity is connected through the plate coil to the positive terminal of the high-voltage source. Very often this capacity C is a variable air or oil dielectric condenser, and its breakdown due to high frequency high voltage will there-

FIG. 9.



fore short-circuit the generator on *D.C.* source. The resultant arcing inside the condenser may also burn the plates badly.

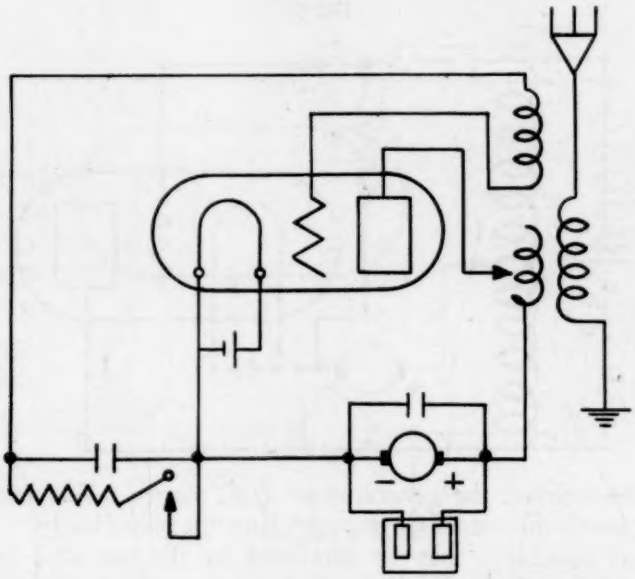
This possibility may be prevented by the use of a second capacity C_1, which should be large in capacity in comparison with C. The condenser C_1, if it is at least one hundred times the value of C, need not be a low loss condenser. It is necessary of course that the condenser C_1 safely stand the voltage of the *D.C.* source.

In a typical form of oscillating circuit, as shown in Fig. 9, the frequency of oscillations is principally determined by the value of the capacity C and inductance L.

As far as the natural frequency of oscillation is concerned, it will remain constant as long as the product of L and C is constant. However, it will be found that the type of circuit shown in Fig. 9 will only oscillate at a given frequency in a satisfactory manner

when the capacity C is under a certain limiting value. This is explained by the fact that certain values of high-frequency voltage are necessary on the grid and plate. If the capacity C is very large the tube will not supply sufficient energy to pass enough current through C to set up across it the necessary grid and plate high-frequency voltage. The lower the value of resistance and the lower the losses in the oscillating circuit the larger the value of C that may be used and still maintain oscillations.

FIG. 10.



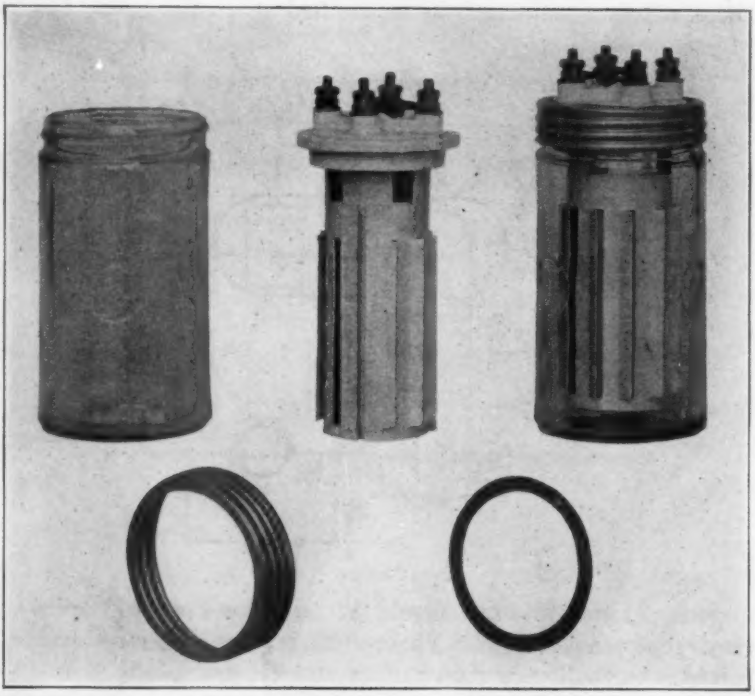
For the type of circuit shown in Fig. 9, the limiting value of C, for the usual types of small tubes running at reasonable values of plate voltage, is in the neighborhood of a maximum of .001 microfarad for a frequency of one million cycles (300 metre wavelength). This is necessarily a very approximate figure because of the many factors which are involved, but it at least gives the experimenter an idea of what not to use.

In the use of high-voltage direct-current generators operated singly or in series, it has been found that when they are employed for supplying energy for tube-plate circuits a considerable strain is imposed on the insulation of the armatures. This is particu-

larly accentuated when the tubes are used for radio telegraphy and telephony where the load fluctuates rapidly or is switched off and on suddenly. For the usual type of circuits, one of which is shown in Fig. 10, the negative side of the generator is practically at ground potential.

This strain which is imposed on the machine is in the form of a voltage surge which momentarily raises the generator voltage

FIG. 11.



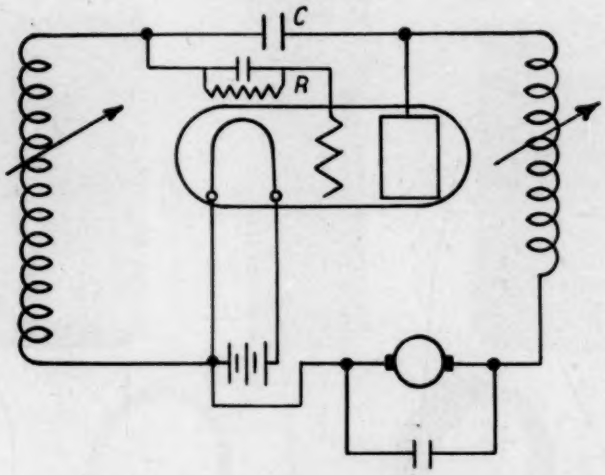
several fold. One terminal being grounded, the strain occurs on the insulation between the frame or armature core and an armature conductor which at the instant is near the positive terminal or brush.

A condenser shunted across the generator terminals, described in a previous paragraph, also acts as a sufficient protection against these voltage strains in the case of very small machines. In the case of generators, singly or in series, for voltages above 500

and power outputs above 50 watts, some sort of protective device to safely limit and discharge this voltage should be used. For this service aluminum cell lightning arresters are very suitable. They should be connected across the generator terminals. In Fig. 10 one protective cell is shown in circuit.

These cells consist of a pair of oxidized aluminum plates immersed in an electrolyte. Many different electrolytes are used to meet special requirements, but for experimental purposes covering a short period of time a saturated solution of borax is satisfactory. These cells are connected in series, and when the oxide film is

FIG. 12.



properly formed one cell should be used for each 300 volts of rated generator voltage. These cells involve the same general principles as the familiar type of electrolytic rectifier.

These cells, owing to the thin oxide film acting as a dielectric, have considerable electrostatic capacity between electrodes, which is an added advantage in their use as protective devices on generators supplying oscillating vacuum tubes.

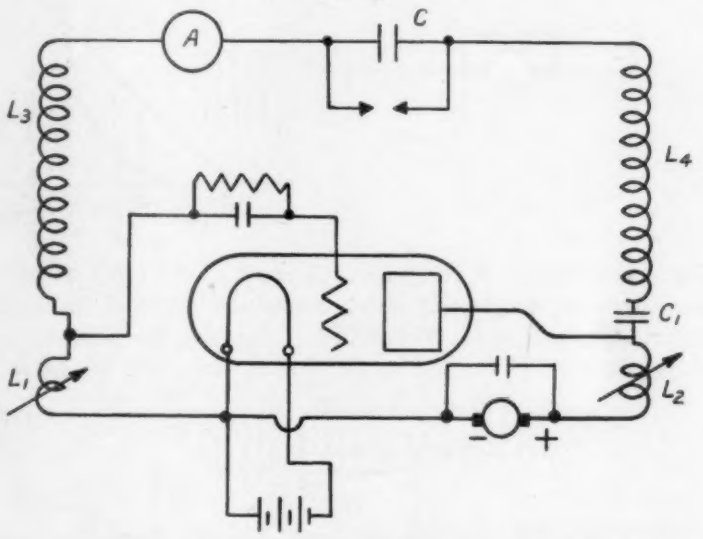
A typical form of aluminum cell protective unit is shown in Fig. 11.

In certain experiments it is often desired to keep the frequency variation of a tube acting as a high-frequency oscillator as small as possible. This is particularly desirable in the calibration of

wave-meters and in measurement work. The variation of frequency due to voltage variations of the power sources can be greatly minimized by using a very high value of grid leak resistance R, as shown in Fig. 12. This applies to practically all types of oscillating circuits.

It is often desired to obtain high-voltage high-frequency energy to test dielectrics and measure dielectric losses. Fig. 13 shows a type of circuit very suitable for using an oscillating tube for this purpose. The frequency of oscillation is largely determined by the

FIG. 13.



period of the simple series circuit comprising L_1, L_2, L_3, L_4, and C. The condenser C_1 is merely for safety, as explained in a previous paragraph, and is large in comparison with C. Maximum output is obtained by variation of L_1 and L_2. The voltage obtained may be computed by measuring the frequency with a wave-meter and reading the current at A, passing through the condenser C of known capacity value. A spark gap across C may also be used to check the value of voltage obtained.

For high voltages the capacity C should be small and the inductance in circuit large. It is also important to have the losses low in the inductances and capacity.

In most power tubes the higher the plate voltage that can be

used the greater the output. Tubes may fail to stand up under an increased voltage for many reasons, but there is one factor in connection with this limitation that is usually overlooked. This

FIG. 14*a*.

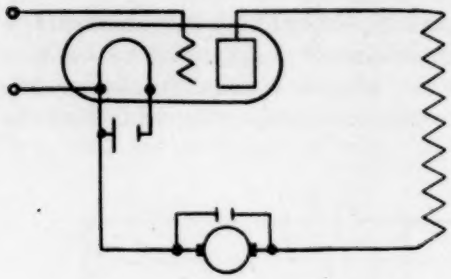
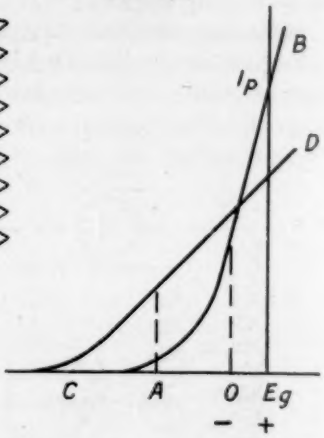
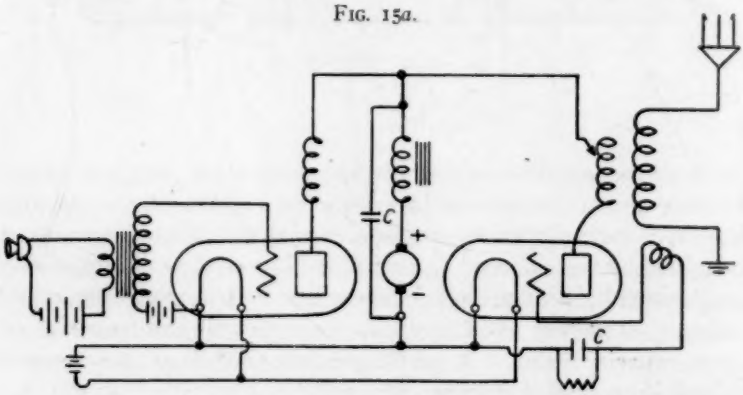


FIG. 14*b*.



factor is electrolysis of the glass. In most of the types of small-power tubes all the lead-in wires are usually carried through a common stem and seal. When this is the case the plate voltage that may be used is limited by electrolytic action in the glass of

FIG. 15*a*.

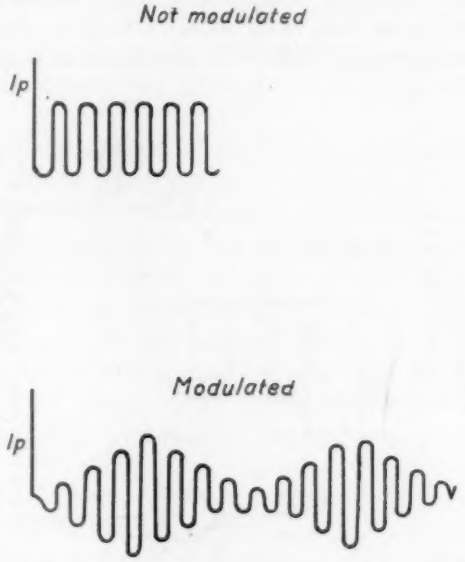


this seal between the plate and grid leads. Hot glass is an electrolytic conductor; that is, the metallic elements in the glass appear at the negative pole. This electrolysis in the course of time, if continued, will ruin the seal, making it leak air, and sometimes

even cracking it. An early indication of this electrolysis which appears long before leakage occurs is a blackening of the grid leads in the glass of the seal near the vacuum end. This action takes place at the grid lead, because this is usually the most negative one when the tube is oscillating.

Therefore, if tubes of this type are operated considerably above their rated plate voltage the life is liable to be terminated

FIG. 15*b*.



by leakage of air into the bulb through the seal rather than filament burnout.

In the various circuits described the source of *D.C.* potential for the plate has been shown in series with the plate inductance. The shunt feed method of connection is just as satisfactory, but is sometimes not quite so convenient for the experimenter with limited apparatus.

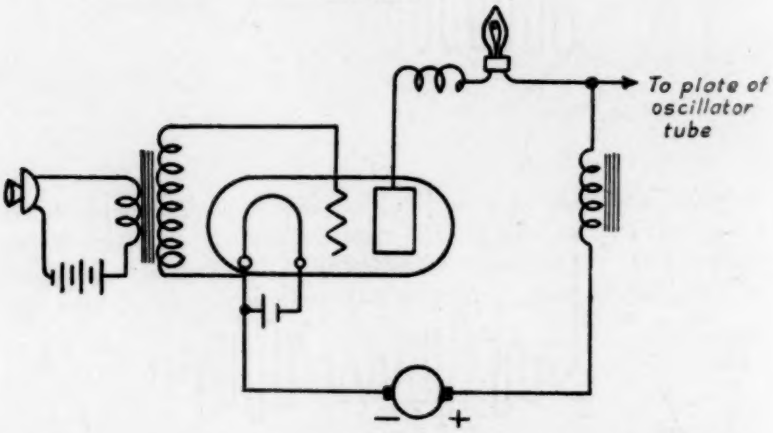
Also the various circuit diagrams in this paper have for the most part shown, for the sake of simplicity, a battery as a filament source and a *D.C.* generator as a plate source. The filament battery may of course be replaced by a generator or transformer and the plate generator by a battery or a rectifier system for producing *D.C.* from *A.C.* at commercial frequencies.

There are a few points of interest that arise when a tube is used as an amplifier for alternating currents of appreciable energy (several watts at least), and when it is used as a voice current amplifier and modulator in radio-telephony.

A very common form of graphical plot employed to show one of the electrical characteristics of a three-element tube is given in Fig. 14*b*. The curve *A-B* illustrates the well-known relation between grid voltage and plate current. This curve assumes a constant plate voltage. However, in many amplifying circuits a resistance, as in Fig. 14*a*, is included in the plate circuit.

When an alternating E.M.F. is connected between filament and

FIG. 16.



grid a corresponding variation in plate current occurs. Therefore an alternating voltage is set up across the resistance in the plate circuit and the voltage of the plate is no longer constant, being higher than normal voltage while the resistance is discharging and lower when it is charging. For this reason the grid voltage and plate current will not follow the curve *A-B*. They will, however, follow a curve of the type *C-D*, because at the low-plate current the plate voltage is higher than normal and therefore a higher negative voltage is required to bring the plate current to zero, while at the higher plate-current end the actual plate voltage is lower and so the plate current is lower.

In most amplifying circuits it is usually desired to keep the grid negative during practically the entire cycle of operation, and

therefore the grid is made normally negative by a so-called biasing potential. It is also usually desirable to make this normal negative potential of a value equal to half the grid voltage required to bring the plate current to zero. This value of normal negative grid voltage should be computed from the curve *C-D* rather than the static curve *A-B*. In other words, the best value of negative biasing grid voltage should reduce the plate current to much less than half the value obtained at zero volts on the grid. A negative voltage that reduces it to about one-quarter value is approximately the best.

The foregoing, of course, does not apply to receiving amplifiers or cases where the amount of plate-current fluctuation is small.

The most usual method of modulation employed for vacuum-tube radio-telephone transmitters is shown in Fig. 15. In this arrangement the output of the oscillator tube is varied above and below its normal amount by variations in plate voltage set up by the amplified microphone voltages. Therefore the peak of plate current in the modulated oscillator tube is considerably higher than in a straight oscillator circuit. More electron emission is therefore required for the modulated tube than for a simple oscillator tube. Very often poor articulation in a radio-telephone transmitter is due to insufficient electron emission in the oscillator tube.

In a radio-telephone transmitter correct wave-length and normal antenna current are not, as in telegraphy, indications that the set is functioning properly. Neither of these factors give any information as to the degree of modulation. The amount of modulation is most satisfactorily obtained by means of an oscillograph, but this is seldom available for use when and where desired.

A simple device to indicate modulation is a miniature tungsten filament lamp in the plate circuit of the modulator tube. This should be chosen of such a rating or so shunted that normally it burns at a dull red. When the microphone is spoken into, it should flash up and the degree of this brightening soon becomes a very good indication to the operator as to whether the modulation is normal or not. This arrangement is shown in Fig. 16.

There are so many things that may prevent a radio-telephone transmitter from properly functioning while showing full radiation current that an indicator, as described above, is very useful.

Studies with the Ionization Gauge. S. DUSHMAN and C. G. FOUND. (*Phys. Rev.*, January, 1921.)—Not many years ago the McLeod gauge for the measurement of gas pressures marked an advance in the technic of the physical laboratory, but the recent improvements in the production of high vacua have made imperative a gauge capable of measuring pressures much less than those within the range of the McLeod instrument. Both in this country and in Japan gauges have been devised in which the pressure of the gas present is inferred from the positive ionization produced in it by a stream of electrons.

In the instrument designed by the present investigators there are two co-axial tungsten filaments surrounded by a molybdenum cylinder. Great care is taken to remove all water vapor and to get rid of gases occluded in the cylinder and in the leads. After this had been accomplished argon was admitted to the space surrounding the spirals. The inner was the cathode, the outer one the anode, and the cylinder was kept at a potential lower than the most negative part of the cathode. The electron discharge from the cathode travels toward the anode and on its way ionizes some of the molecules of the gas in its path. The positive ions thus produced are drawn over to the negatively charged cylinder. The larger the number of gas molecules in the way of the electrons the larger the number of positive ions resulting and the greater the positive charge conveyed to the cylinder. By comparing the new type of gauge with the McLeod form for the same gas pressures it is found that the positive ionization current is directly as the gas pressure up to a certain pressure which varies with the electron current employed. This justifies the employment of the ionization current as a measure of the pressure. Pressures as low as .0001 bars have been measured, corresponding to one ten-millionth ampere of positive ionization current.

When the outer spiral is the cathode and the inner one the collector of positive ions, while the cylinder serves as anode, the instrument is applicable to a wide range of pressures.

G. F. S.

Radiotelephony on the Farm. (*Popular Sci. M.*, November, 1920, p. 65.)—Michigan farmers who live far away from civilization will soon be able to know what is happening in the big city at any time of the day. The Michigan Agricultural College has planned a system of wireless telephones to be installed on all the large far-distant farms.

The Michigan farmer will be able to know at all times the market prices of his products. He will receive weather forecasts and listen to lectures or music when he has nothing else to do. His equipment provides for receiving messages, but not for sending them.

THE ECONOMIC ASPECTS OF RAILWAY ELECTRIFICATION.*

BY

A. H. ARMSTRONG, M.E.

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AN industry valued at some nineteen billions of dollars cannot be ruthlessly tampered with and escape serious economic disturbance, especially when it is closely interwoven with our national prosperity. The story of our railway development is part of the written history of the country. It is, therefore, a matter of grave national concern to properly diagnose the true nature of the ailment affecting our transportation system and prescribe the treatment of greatest promise for its future recovery.

To the great main lines binding East and West, North and South have been added branches reaching into new country and bringing more products to swell the ever-growing traffic of the parent stem or main line. Engines of greater power have tried to cope with the demands of an ever-increasing traffic and have been assisted by such improvements as heavier rails, automatic airbrake, grade revisions, block signals and better terminal facilities. Finally, however, when congestion on some main lines became too great with steam-engine operation, it was necessary to add second, or even a third or fourth pair of rails.

The limitations of the steam engine are not so keenly felt upon branch or feeder lines with the infrequent small tonnage trains incident to this service. The congestion on main lines has, in many cases, however, become most acute, and it is under such conditions that the steam engine plainly imposes its limitations upon the physical and economic showing of a railway property. Appreciating the need of building new lines into new country to some limited extent, the big problem before us is to greatly improve the railway machine we have already created. We want cheaper and quicker transportation over existing tracks, more reliable service, less congestion at terminals and proper provision

* Presented at a meeting of the Electrical Section held Thursday, February 24, 1921.

for the future growth of traffic that in the past has doubled every twelve years. This is a large order to place upon steam-engine operation, now constituting the foundation upon which our present railway system rests and which many think is one of the fundamental causes of its economic collapse.

We have practically built up our national life around the possibilities and limitations of the steam engine, taking advantage of such improvements from time to time as the advance in its development permitted. But at all times the steam engine has been the determining factor in establishing the entire railway development and has fixed present standards of trainloads, speeds, delays, division points, labor conditions, wages, even location of road and the multitude of factors entering into the vast railway problem. And this big machine has arrived at the point where it costs so much to keep it running that even greatly increased rates will not pay the bill and leave enough over to pay a fair return upon the capital invested. In this respect, a fair return is placed by our government at the modest figure of 6 per cent. of present valuation.

If we are to continue to exchange our eastern manufactured for western raw products, the carrying charges over the intervening one to three thousand miles must be kept at a minimum. In no country in the world does one man's labor produce so much, and specialized communities cannot continue to exist as such without the cheapest kind of transportation to facilitate the movement of surplus product from one end of the country to the other. The answer to the present sleeping sickness attacking the prosperity of both railways and industries cannot be found in the merry race of higher transportation rates climbing after increasing labor and fuel costs.

We are facing the facts of an eight-hour basic working day, with time and one-half for overtime, greatly increased wages, fuel prices at levels never before reached and maintenance costs that are practically prohibitive. We are told that vast sums of money must be expended on construction and new equipment to make good the deficiencies of the war period and provide for future growth in traffic. But no assurance is offered that such material additions to capital account will result in reduced transportation rates, better service and a higher economic return upon a property already equal in value to our entire national war debt.

In fact, it is apparently not possible to make such fundamental changes in railway operation and economics as are evidently necessary to accomplish the desired results simply by investing still greater sums in the old steam-engine facilities that have, in the opinion of many, failed to advance with the needs of the times.

Such minor improvements in steam-engine design as are already available or in view do not hold promise of any real relief from present operating conditions. The steam engine seems destined to spend the greater part of the year tied to the coal bunker, water tank, round house, ash pit, and repair shop with too little time left for the actual haulage of trains. It is wasteful in man power, especially on heavy grade divisions, and in these days of high wages and short working hours, with severe penalty for delays leading to overtime, this low efficiency in utilizing engine and train crews is fatal to economic success. It is a notorious waster of fuel, burning a quarter of all the coal mined, and finally its cost of upkeep and depreciation are so high as to constitute a most serious percentage of the total operating expense.

Perhaps this may seem a rather sweeping criticism of the steam engine. On the contrary, such facts are well known, but perhaps not fully appreciated unless compared with the operating records of other types of motive power. The steam engine has held supreme in the railway field for so many generations that to some it seems heresy to question its exclusive right to dominate it for all time.

During the past twenty years serious competition has entered the field of steam railway transportation. Electric railways have taken over the short-haul passenger traffic and in addition has created travel that never was enjoyed by steam roads. The gas motor truck has captured a great part of the short-haul express movement at the expense of both the steam and electric railways. To be sure, this motor-truck traffic is partly a left-over from war conditions which demanded quick deliveries, regardless of cost, while it has thus far borne no reasonable portion of public road upkeep. Nevertheless, railways must reckon with short-haul motor-truck competition in the future to an extent not as yet clearly defined.

The driver of any flivver will declare that he dodges more tonnage carried on motor trucks over main public roads than is in evidence on the railways they parallel. When comparatively small

trucks bumping over public highways, not too well maintained at the taxpayer's expense, can successfully compete with rail transportation, something has evidently happened during the past few years which calls for a readjustment of our previous ideas of transportation. It takes a pull of approximately 50 pounds to move a ton over the varying grades and surfaces of our highways. The same 50-pounds pull will haul 10 tons of load over steel rails. Moreover, trucking power is obtained from one of our most expensive fuels, and gasoline substitutes are already being eagerly sought after to supplement a product that is fast becoming inadequate to meet the growing demands.

The late J. J. Hill built up the Great Northern property by an early recognition of the fact that while receipts are proportional to ton miles, operating expenses are determined by train miles. While efforts to increase trainloads were most successful in building up that great property serving the needs of a new and sparsely settled country, does not the growing competition of the motor-truck cast serious doubt upon the wisdom of too close adherence to the same inflexible principle when applied to the conditions obtaining in the congested districts of the East? Admitting the lower expense of train crews with the heavier train loading, is it not possible that the delays inseparable to slow-drag freights have materially contributed to establishing the motor-truck industry that offers as its one chief asset quick delivery? In his efforts to reduce ever-increasing operating costs, has the railway operator been too busily concerned in running his huge transportation machine to fully observe the industrial needs of the country and appreciate the evident value placed by the shipper upon speed?

We must admit that the American visiting Europe for the first time is quite likely to look upon its railways as somewhat of a joke. The small cars, light engines and low tonnage trains contrast unfavorably with American practice as to size. Afterward, however, the interesting discovery is made that most excellent service is given to a densely populated country by these small frequent trains and that American methods would possibly not suit such conditions at all.

It is a wide jump from the motor truck on our public roads to European railways, but can we not learn the same lesson from each, and that is that our present railways do not properly serve

the more congested districts through which they pass and that our railway directors have themselves to blame if they do not profit from a recognition of the fundamental facts underlying the growing menace of motor-truck competition? Quite evidently our railways, as now operated, do not provide the service our eastern shippers want.

Shall the short-haul freight traffic be surrendered to the motor truck as was the short-haul passenger business to the electric railway, thus leaving our steel highways free for heavy through-train movement only? Can such through traffic alone pay for the upkeep of the property? If not, what steps can be taken to compete for the short-haul business? These are most pertinent questions in view of the fact that many more millions are being spent in building macadam roads and motor trucks than are apparently available for railway betterment.

Electricity has amply proved its effectiveness in the operation of light high-speed trains in congested zones. Steam traditions of a busy track have been shattered by electric-train performance. With such successful examples before us as our elevated roads, subways and electrified railway terminals, there can be no dissenting voice raised to challenge the statement that the adoption of the electric motor introduces the means of making radical changes in steam-engine practice in congested terminals. Not only is the electric motor preëminently fitted to meet the needs of short-haul, frequent-stop service, but it gives opportunity to relocate and redesign the whole terminal railway property along lines impossible to the steam engine.

Contrast the Grand Central Terminal of to-day with that of 1906 before electricity had replaced steam. The air rights over the yards have become most valuable, huge buildings have been erected, adjacent property greatly increased in value and in fact a new residential, hotel and office centre has been created in what may now be called the centre of New York City. The Pennsylvania Terminal eliminates the handicap of the Hudson and the whole picture is rounded out by the growing subway facilities. In fact, New York City is being electrified—that is, as regards its passenger transportation—and a similar transformation is about to be commenced in Chicago with the substitution of electricity for steam on the Illinois Central.

But that is not all. The way has been shown to solve the

equally vital problem of handling freight and express matter in city terminals. The very nature of a steam engine has banished the railway terminal to the outskirts of a city; or has it been that our cities have developed as far away as possible from an undesirable neighbor? In any case the steam terminal is not immediately adjacent to the shipper or centre of distribution, nor is it well adapted to the expeditious and economic handling of freight. Electric terminals, on the contrary, may be located with proper regard to the needs of the shipper, in the very centre of our biggest cities, if necessary. Tracks may enter terminal warehouses on two, three or more levels and use but a fraction of the real estate required for an open steam terminal yard. In other words, there are apparently just as great opportunities to effect a transformation in our freight terminal facilities as have already been partly completed in passenger stations and approaches. Furthermore, the solution of the freight terminal problem will go far towards settling the question of short-haul competition, and electricity opens the way to overcome the handicaps of the steam engine which is now blocking the further development of the transportation machine.

Approximately one-quarter of all the coal mined in the United States is consumed by our railways, and a great part of this fuel, estimated at possibly one-third of the total, is wasted in so-called standby losses in the 63,000 engines utilized in hauling out trains. The modern engine is equipped with all possible improvements designed to increase its fuel efficiency, but, nevertheless, its main purpose, to which everything else must be largely sacrificed, is to render reasonably reliable service in hauling trains under all conditions of weight, speed, grade and climatic changes. The fuel economies which it is possible to introduce in a moving structure cannot compare in effectiveness with the developments incorporated in modern electric-power stations. The restrictions of track gauge, wheel base, axle weights and running qualities of the steam engine must impair the effectiveness of its boiler plant. Furthermore, each steam engine is a complete individual power plant, subject to all the variations in load incident to hauling trains over a broken profile, with intermediate and terminal delays. The boiler must be kept hot at all times, regardless of whether the engine is doing work or not, thus giving rise to the standby losses that form so great a proportion of the total fuel consumed.

The electric locomotive, on the other hand, comprises in the electric motor the most efficient and flexible known means of transforming potential into mechanical power. The variations in load of each individual locomotive in operation are largely smoothed out when superimposed upon the average demands of possibly 50 or more other locomotives, with a resulting load curve at the power house supplying them all that is sufficiently uniform to insure the most efficient use of fuel. The steam turbine and auxiliary station apparatus have been developed to such a high state of efficiency that manufacturers' guarantees can be secured of eight pounds of water per electrical horsepower. Large power houses are in operation at the rate of 14,000 B.T.U's, or approximately one pound of high-grade coal per electrical horsepower-hour output.

Based upon the performance of sixty huge electric locomotives operating over nearly 700 miles of route on the C. M. and St. P. Railway, and on other facts of record, it has been estimated that the passenger and revenue freight tonnage of the United States could be hauled by electric locomotives for one-third the coal now burned under steam-engine boilers. Not even the most ardent electrical enthusiast advocates the immediate electrification of all our steam railways, but the above comparison is offered as a measure of the magnitude of the present wastefulness of burning fuel and the ultimate goal toward which the electrification movement is directed. In this connection, it is of interest to note that railway fuel carried in cars and steam-engine tenders equals approximately 20 per cent. of the total revenue freight tonnage carried over our rails, and practically all of this non-paying tonnage could be saved by electrification. The adoption of electricity, therefore, would immediately increase the carrying capacity of our railways a fifth by eliminating the railway coal-carrying business from the rails.

While our country boasts of its almost unlimited fuel reserves, and is wasteful to a degree, such is not the condition in other parts of the world. England, France, Belgium, Switzerland, Sweden, Italy and even bankrupt Austria—all have entered upon an immediate program having for its final objective the universal electrification of the state and privately owned railways in those countries. Shortage of fuel is the most pressing incentive, and available water powers will be utilized to the utmost. A constructive government policy makes such an enormous undertaking possible, and is in-

marked contrast to the politics that have brought our own railways to such a sorry financial plight.

In many instances, congestion on mountain-grade divisions has reached such a point that additional rails must be laid to obtain the needed relief with continued steam operation. It is in just such service that the electric locomotive offers very great advantages. Drawing power from a practically unlimited source of supply and free from the structural restrictions of the steam engine, the electric locomotive may be built to deliver any tractive power at any speed required by the operating needs of the service. Steam engines are now in operation that will give a maximum draw-bar pull up to the limit or standard draft rigging, but the speed of such powerful Mallet engines is so low as to greatly restrict the rapid movement of freight over heavy mountain grades. Not only can electric locomotives develop equal pull, but sustain full tractive power at double the speed possible with the heaviest steam engine.

Thus while one St. Paul electric locomotive hauls a 3000-ton train up a 1 per cent. grade unaided at a speed of 15 miles per hour, it is quite probable that we may anticipate the early demand for still greater power. Indeed, draft gear on commodity freight cars at no distant date may be so improved as to permit hauling a 5000-ton train up a 1 per cent. grade. This would demand a tractive effort of 135,000 pounds at the drivers and an output of the electric locomotive of 5400 h.p. at a speed of 15 miles per hour. Higher speeds at the same tractive effort are entirely feasible; in fact, the manufacturers of electric locomotives would to-day contract to build such an enormous machine and guarantee its output with no hesitancy as to their ability to make good.

Full appreciation of this fact of the availability in one locomotive structure of power far in excess of anything possible with the steam engine, opens up unlimited opportunities for readjustment of present methods of operating our steam roads. In other words, instead of steam-engine railroading, as in the past, we are offered the opportunity to enter into an era of real unrestricted railroading with the motive-power lid removed.

The development of the more powerful electric locomotive is a determining factor in the matter of grade revision, double tracking and mountain-division operation. Not only does the operation of the electric locomotive greatly increase the tonnage-carrying

capacity of present tracks and postpone for an indefinite period the day of laying additional rails under most difficult and expensive conditions, but it also greatly reduces the hazards of heavy-grade railroading by utilizing the so-called "regenerative braking" feature on down-grade movement. It is an impressive sight to witness a 3000-ton train being hauled up the 1.66 per cent. grade over the divide at Donald and dropped down 2000 feet at Piedmont on the 21 miles of 2 per cent. descending grade of the C. M. and St. P. without once using the airbrakes. The mechanical power developed by the descending train is "regenerated" and returned as electricity to the trolley to be used by some other train, instead of being wasted in heating brake shoes and wheels inevitable to the use of airbrakes. Besides eliminating much of the risks of grade movement, electric braking contributes to the relief of traffic congestion, as it permits using higher speeds on the down grades with safety.

One of the marked advantages promptly discovered in the electric locomotive is its great reliability and consequently low cost of maintenance. For a period of ten years, or until the high cost of living struck the electric locomotive as well, the 120-ton New York Central electric locomotives were maintained for approximately 3½ cents per mile run, a noteworthy achievement when compared with the upkeep of steam engines of equal power. Even during the year 1919 the St. Paul electric locomotives, weighing nearly 300 tons and making some 60,000 miles a year, were maintained for approximately 15 cents per mile run, or less than one-third the upkeep of Mallet engines of equal tractive power.

And so this discourse could continue to present facts showing the especial fitness of the electric motor for the varied needs of rail transportation. While our railways are used for the wholesale movement of passengers and freight, they are, nevertheless, engaged in the retail burning of fuel under 63,000 individual boilers with the waste inseparable to such a necessity. The adoption of electricity assures such a vast fuel saving that even the most careful estimates appear startling to those who have not studied the facts available.

Electrification of mountain divisions has demonstrated a large increase in single-track capacity, estimated by some to be at least 50 per cent. greater than possible to steam-engine operation. In many instances this improvement can be secured at a less expendi-

ture than would be required for double tracking and also shows a greater return upon the new capital charge incurred.

Cold weather does not affect the electric locomotive at all, in striking contrast to the frozen steam engines of the winters of 1917–18, while its greater safety and reliability on grades are matters of record.

Electrified terminals and approaches to large cities should revolutionize present steam-engine practice, and not only effect economies in operation but greatly stimulate traffic by introducing radical improvements in facilities. In other words, terminal electrification offers attractive opportunities to both the holder of railway securities and the shipper.

With no immediate prospect in sight of any material reduction in the price of labor, its output must be increased, and electric operation has demonstrated its effectiveness in this direction both on the road and in the shop, together with complete elimination of coal and water facilities, ash-pits, turntables, round-houses, etc. In addition, locomotive division points may be indefinitely extended, and already runs of 440 miles are being made with a single electric locomotive.

All these improvements in the electrified railway property will cost large sums of money. In some items of operating expense, such as fuel, crews and maintenance, direct savings are effected of such magnitude as to show a reasonable return upon new capital charges incurred in electrification. The argument for electrification, however, is built upon a broader foundation than a direct return upon the investment involved. In fact, it has to do with the vital question of the future growth of our transportation system and its effect upon our national prosperity.

We have come to a period in our railway development where many regard the steam engine as inherently responsible for much of the physical and economic troubles now most painfully apparent. If we may correctly interpret the needs of our railways, they require a major operation rather than the application of a bit of plaster. The steam engine may well retire with full honors from a field which has outgrown it and give way to its younger rival. Youth must be served.

A SENSITOMETRIC STUDY OF THE REDUCTION OF DEVELOPING-OUT PAPERS.*

BY

LOYD A. JONES and C. E. FAWKES.

THE action of photographic reducers upon the silver deposits in photographic plates and films has been studied rather extensively by various workers in the field of photographic research. These investigations have been carried out both from the practical and theoretical point of view. Among the most prominent researches of this nature may be mentioned those by Luppo-Cramer,[1] A. and L. Lumiere and Seyewetz,[2] Stenger and Heller,[3] Deck,[4] Nietz and Huse,[5] and Sheppard.[6] Practically all of this work has dealt with the reduction of density in the case of photographic materials coated on transparent supports, such as plates and films, for not until a satisfactory method for paper sensitometry [7] was available could the usual *H.* and *D.* methods be applied to the study of the reduction of density in photographic printing-out papers.

Since it is evident that the quality of the photographic print may in some cases be improved by the proper reduction of density, it seemed advisable to investigate the effect of various reducers when used for this purpose. The problem is considered in this paper entirely from the sensitometric standpoint, very little attention being paid to the theory of the action of these reducers on the deposits, and all conclusions relative to the merit of the various reducers tried are based upon the consideration of the sensitometric curves rather than upon actual prints. The sensitometric method for the study of the characteristics of photographic ma-

* Communicated by Dr. C. E. K. Mees, Director. Communication No. 111 from the Research Laboratory of the Eastman Kodak Company.

[1] *Colloid Chem. und Phot.*

[2] *Bull Français, Soc. de Phot.*, 1901.

[3] *Zeit. fur wissenschaft. Phot.*, 1913.

[4] *Australian Phot. Rev.*, 1916.

[5] *Brit. Jour.*, Oct. 27, 1916.

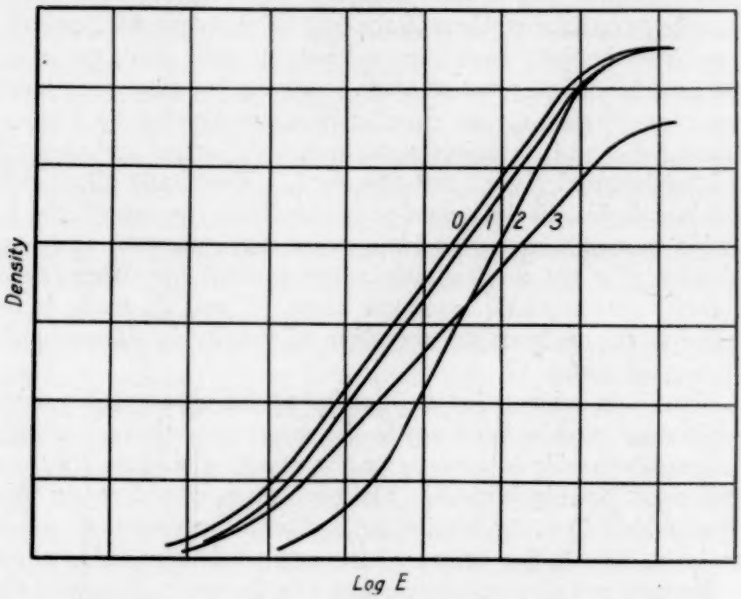
[6] *Phot. Jour. of Amer.* 55, 1918.

[7] Jones, Nutting and Mees: *J. Roy. Phot. Soc.*, Dec., 1915.

terials has been discussed at length in previous papers (footnotes 5, 7, and 8), and to these the reader is referred for the details of such methods.

Excessive density in all parts of the print or in certain limited regions may result either from overexposure or overdevelopment of the print or because a paper of the proper contrast was not used in making the print. It is doubtful if reduction can completely correct the latter defect, but certainly some improvement

FIG. 1.

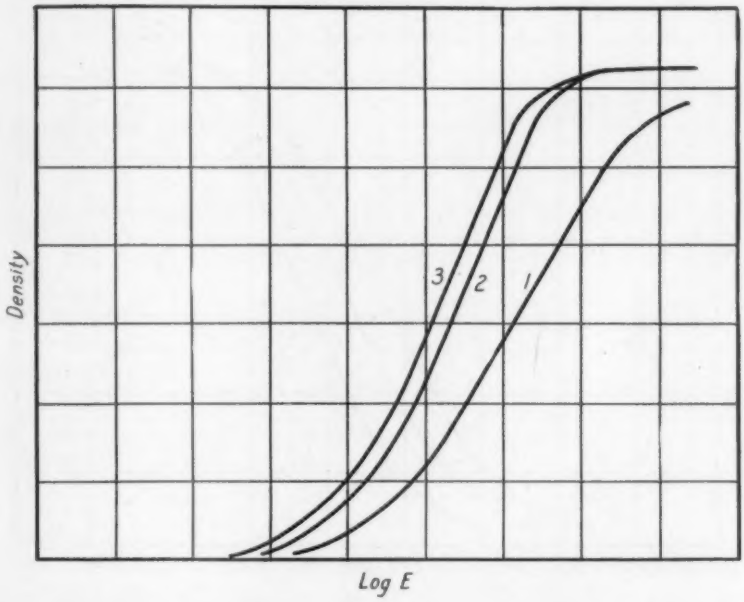


may be effected. From a consideration of the shape of the characteristic curves of various papers, it will be seen that in order to improve the quality of the print in some cases reduction of density should be such as to cause a decrease in contrast, while in others the reduction should increase the contrast, while a third possibility may require reduction which will reduce the density in such a way that no change in the contrast is produced. These three general types of reduction may be illustrated by the curves shown in Fig. 1. Thus, if we consider the Curve 0 as the characteristic

[8] JOUR. FRANK. INST., March, 1918, p. 389.

of the material considered, then Curve 1 will represent the result when this material is subjected to the action of a reducer producing no change in contrast. Such reducers will be referred to as Type 1. Curve 2 represents the result when the same material has been subjected to a reducer which produces an increase in contrast, this increase in contrast being caused by a more vigorous action of the solution upon the low densities than on the high. Reducers of this kind will be referred to as Type 2. Curve 3 represents

FIG. 2.

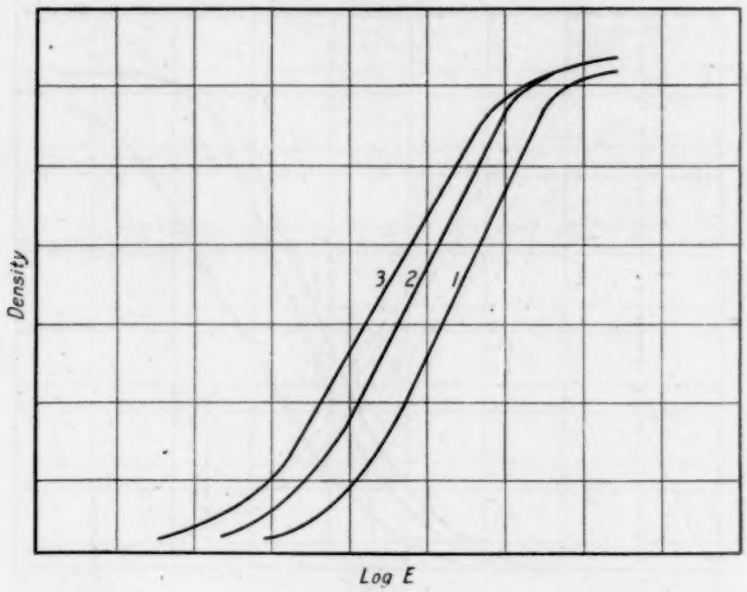


a case of the decrease in contrast, and results from the proportional reduction of all densities, regardless of their magnitude; that is, each density is reduced to the same percentage of its original value. Reducers having this action will be referred to as Type 3. No distinct line of demarcation can be drawn between these various types, since some reducers have characteristics intermediate between those represented by the typical curves in Fig. 1.

In Fig. 2 are shown the characteristic curves of Iris Artura paper. Curves 1, 2, and 3 represent the change in density with increasing times of development. From the shape of these curves,

it is possible to draw conclusions as to the action of the reducer, which can be used successfully to correct overdevelopment in the case of this material. It will be noted for the longer times of development that for the correction of overdevelopment a reducer of Type 1 will be necessary, while if it be desired to obtain results comparable with those resulting from underdevelopment in such a print a reducer of Type 3 will be required. In Fig. 3 are shown the characteristic curves of Velox, the different curves

FIG. 3.



representing increasing times of development. It will be noted in this case that for the correction of overdevelopment a reducer of Type 1 is necessary.

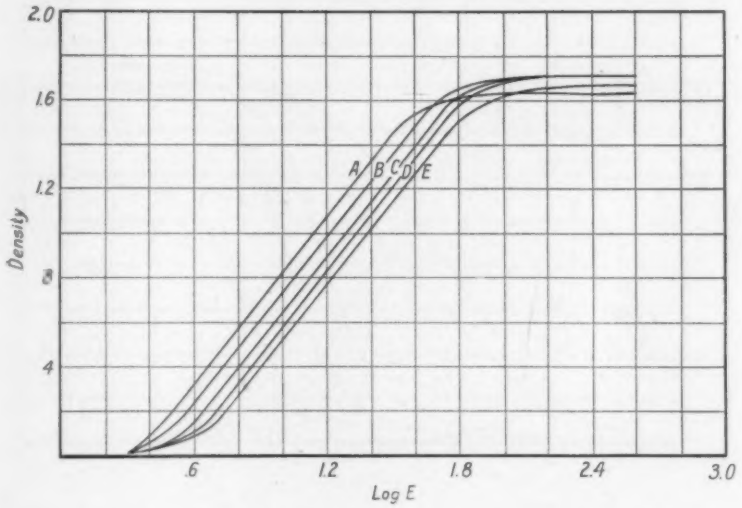
Ten reducer formulæ were chosen principally from the *British Journal Almanac* and prepared full strength. The list included permanganate, bichromate, Eder's and iodine-cyanide, whose action upon negatives is of Type 1, corresponding to the curve shift 0 to 1 (Fig. 1). Farmer's and Belitski's reducers were selected as being typical of Type 2, while sodium hypochlorite, ammonium persulphate and the Nietz-Huse proportional reducer

were taken as representative of Type 3. As typical examples of the developing-out papers the following were chosen:

Paper	Grade	Relative Speed
Azo	E-Hard X	Medium Fast
Velox	Regular Velvet	Very Fast
Artura	Iris B	Slow

These papers were exposed in the non-intermittent sensitometer in the usual way, and strips consisting of twenty-six steps increasing in exposure by consecutive powers of the cube root of two

FIG. 4.

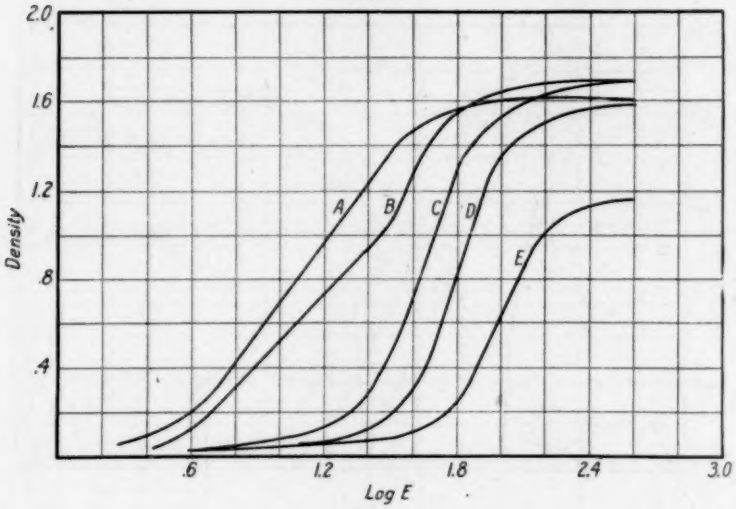


were obtained. These exposed strips were then developed in the recommended solutions, so as to obtain normally and over-developed results.

A number of preliminary tests were made with each reducing solution to find the dilution necessary to obtain uniform and controllable action. From these preliminary tests the most satisfactory concentration for use in the subsequent study of reduction was determined. These dilutions and the formulæ are given later in this report. All reduction was carried out at a temperature of 20° C. Careful observations were made relative to the color of the deposit resulting from the action of the reducing solutions for various lengths of time, and also upon the staining of the image

and gelatine by the reducers and their reaction products. Some staining was observed, but in those reducers which were found to be otherwise satisfactory it was possible to remove these stains by returning the print after reduction to the ordinary acid-fixing bath for a short time, this, of course, being followed by washing and drying in the usual way. After being reduced, the reflecting power of the various areas of the sensitometric strips were read on the reflectometer and the characteristic curves plotted in the usual way. These curves were then compared with one plotted

FIG. 5.



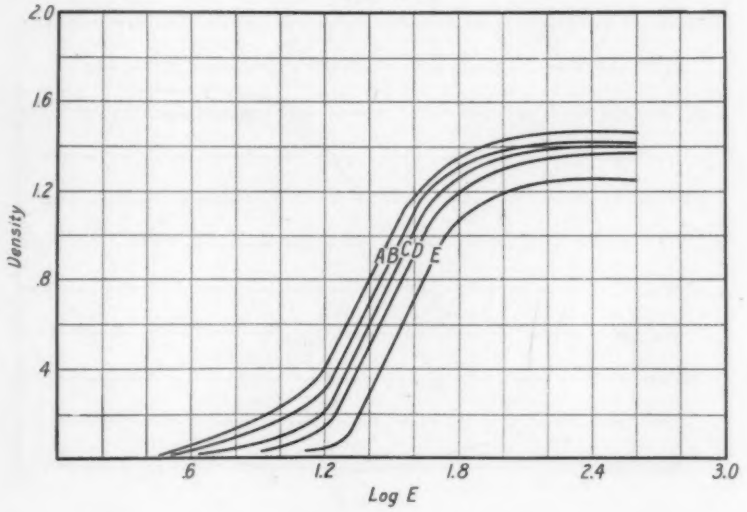
from the results obtained from the non-reduced strip. By a comparison of the curves thus obtained, information is secured from which it is possible to predict the action of the various reducers upon prints.

A. REDUCERS OF TYPE I.

1. Potassium Permanganate.—This reducer converts the silver of the deposit into silver sulphate, which is soluble in the solution. The reduction is rapid, and no stain is produced either in the silver deposits themselves or in the gelatine. With prolonged action it gives a slightly grainier appearance to the areas of low density. In Fig. 4 is shown a series of curves obtained with this reducer on Artura paper. It will be noted that the

straight-line portions are almost exactly parallel to each other. Curve *A* was plotted from the unreduced strip, while *B*, *C*, *D*, and *E* were obtained by subjecting identical strips to the action of the solution for 45, 60, 90, and 120 seconds, respectively. It will be noted that the maximum black on the reduced strips is apparently higher than that of the unreduced. This is because the densities plotted are measured relative to the fog density of the paper. The action of the reducer cuts away this fog density and tends to give slightly higher maximum density when measured against

FIG. 6.

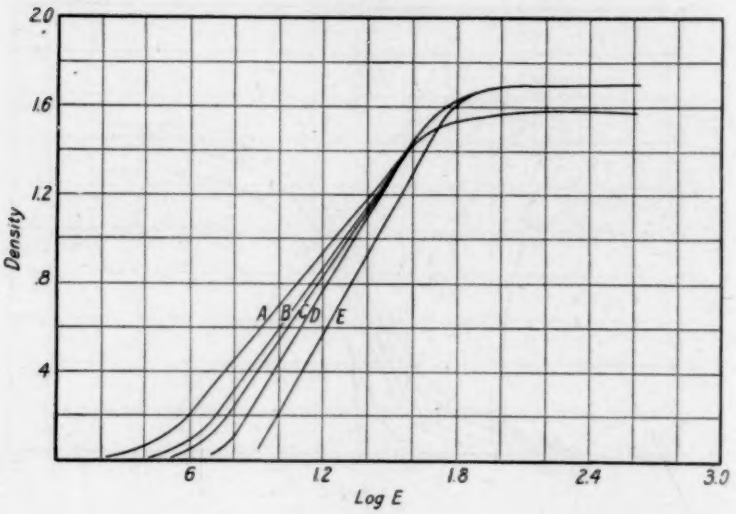


the unexposed regions of the paper. The action of this reducer on Velox and Azo is the same as that on Artura (as shown in Fig. 4), with the exception that in the case of Velox there is slightly more reduction of the highlight regions. This reducer, as shown by the curve in Fig. 4, is an almost ideal corrective for cases of overdevelopment.

2. *Belitski's Reducer.*—The image is converted by the ferric oxalate and soluble chloride solution to silver chloride, which is then dissolved by the hypo in the reducer. The action is very rapid at the concentration recommended, and, although stainless and uniform in action, it seems to give a slightly brownish-colored deposit when the reduction is carried to any length. In the case of

slight reduction, this tendency to give brownish deposits seems to be entirely absent. On Artura it acts as it does on negatives, giving a transformation of Type 2—that is, reducing the lower densities more rapidly than the higher ones and therefore giving an increase in contrast. Upon Velox and Azo its action is of Type 1, the straight line portion of the curve remaining parallel to that of the unreduced strip. In Fig. 5 is shown a set of curves obtained from sensitometric strips made on Artura and treated with this reducer, the times of action being 45, 60, 90, and 120

FIG. 7.



seconds, respectively, for curves *B*, *C*, *D*, and *E*. In Fig. 6 are given the curves showing the action of this developer on Azo. These curves are almost identical with those obtained on Velox. It should be noted that while the straight-line portion of the reduction curves are practically parallel to that of the unreduced, the highlight densities are attached more vigorously than those of the halftone and shadows, thus producing a cutting away of the toe of the curve in the case of the reduced strips.

3. *Iodine-Cyanide.*—This reducer applied on prints falls in Type 2. Further reference is made in that classification.

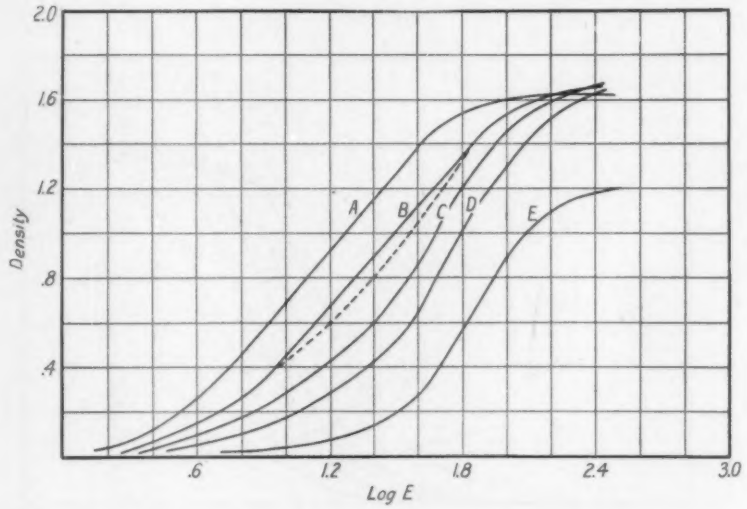
4. *Eder's.*—This reducer was found to be unsatisfactory, owing to the unevenness with which action occurred.

5. Bichromate.—This also was found unsatisfactory, owing to excessive staining of the gelatine.

B. TYPE 2.

1. Iodine-Cyanide.—The free iodine in the solution converts the silver of the image into silver iodide which is soluble in the potassium cyanide of the solution. This reducer acts rapidly, uniformly, and is clean and stainless. No mottling effect is noticeable even in the lowest density. It is, however, extremely poison-

FIG. 8A.



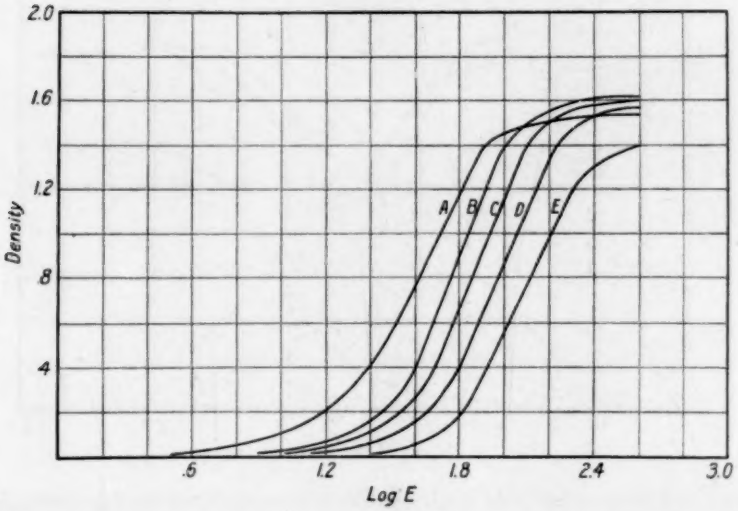
ous, and therefore it is undesirable to recommend it for general use. In Fig. 7 are shown a series of curves plotted from strips made on Artura Iris and reduced in this solution. Curve *A* is that of the unreduced strip, while *B, C, D,* and *E* received treatments of 30, 45, 75 and 120 seconds. It will be noted that the upper portion of the curves are changed very slightly, while the highlight and lower half-tone densities are cut away, producing an increase in contrast. The action on Velox and Azo is identical with that on Artura. During the reduction, the paper stock of the print appears a brilliant blue, due to the presence of starch iodide which can be completely removed by soaking in an acid-hypo solution after the reduction is completed.

2. Farmer's Reducer.—The silver is converted by the potassium ferricyanide into silver ferrocyanide, which is soluble in the hypo of the solution. A slight staining of the gelatine was noticed in some cases, but in other respects the action is identical with that of the iodine cyanide. The curves shown in Fig. 7 are typical of Farmer's reducer on all kinds of paper.

C. TYPE 3.

1. Nietz and Huse Proportional Reducer.—The reduction in this case is due to a combination of the actions of ammonium per-

FIG. 8B.

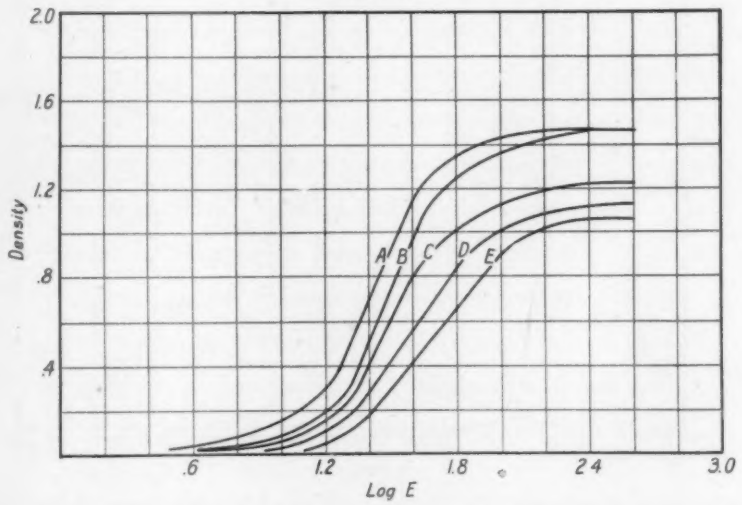


sulphate and potassium permanganate. Each reducing agent retains its chemical identity. The permanganate attacks the lower densities while the persulphate is acting upon the higher densities. Used on prints, the action is very rapid, uniform and stainless. Its concentration can be adjusted to any particular paper reduction problem with great ease. In Fig. 8A are given curves plotted from strips made on Artura Iris treated with this reducer. In Fig. 8B are shown the results on Velox, and in Fig. 8C those obtained upon Azo.

2. Ammonium Persulphate.—Various attempts have been made to explain the peculiar action of this reducer. Luppo-

Cramer has advanced a protective colloid theory based on the idea that the chemical composition of the photographic image is dependent upon the exposure. The images having higher density are, therefore, in some way different from those of lower density, and this difference is of such a nature that the ammonium persulphate reducer attacks densities above a certain critical value very vigorously, while the action of lower densities is almost inappreciable. A catalytic theory of the action has been proposed by E. Stenger, which assumes a selective action on the higher densities due to the presence there of an excess of silver ions. In Fig. 9

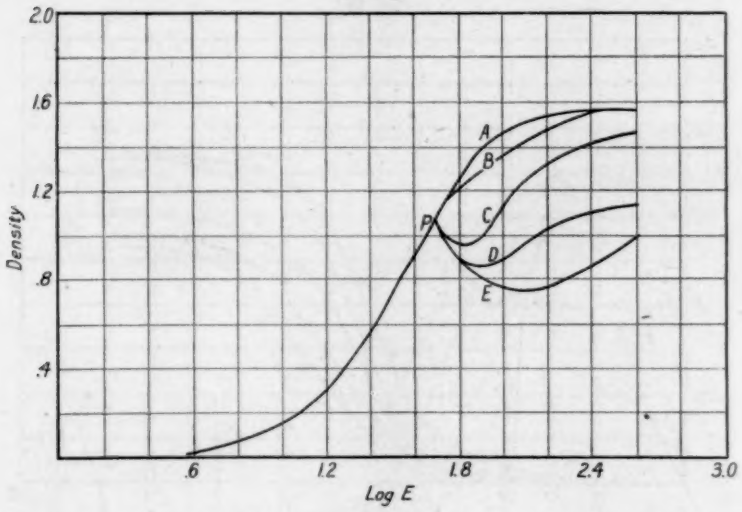
FIG. 8C.



are shown curves illustrating the action of this reducer on the Velox strips. It will be noted that above a certain critical density designated by the point *P* the action is very vigorous, while for densities lower than that no measurable action occurs. Strips reduced in this solution, therefore, have very peculiar density characteristics. For instance, a strip treated four minutes exhibits a density maximum in the half-tone regions, the shadows being cut away, so that they are actually lower in density. It is evident that this reducer is unsatisfactory for most purposes, although it is possible that it may be utilized to advantage in some special cases where it is desirable to reduce the shadow densities without effecting highlight and half-tone regions. By the addition of a soluble chloride

or of silver ions (silver nitrate) to the reducing solution, the character of the action is changed radically, and the reduction becomes strictly proportional. In Fig. 10 are shown the curves obtained from strips made on Velox reduced in an ammonium persulphate solution containing 10 per cent. sodium chloride. Curves *B*, *C*, *D*, and *E* were obtained from strips which had received 2, 3, 5, and 7 minutes' treatment. It will be noted that the reduction is very nearly proportional, the action is uniform, and no staining of the deposit or gelatine is perceptible. It should be pointed out that

FIG. 9.



the results shown in Fig. 9 were obtained by the persulphate reducer when made up with distilled water, the only difference in the solution used for obtaining results in Fig. 10 being the addition of 1 per cent. of sodium chloride.

SUMMARY.

1. Several reducers commonly used for the reduction of negatives have been studied and modified in such a way as to be applicable to the reduction of prints made on developing-out papers.

2. A classification has been made on the basis of the character of the modification in the characteristic curve obtained with the several reducers.

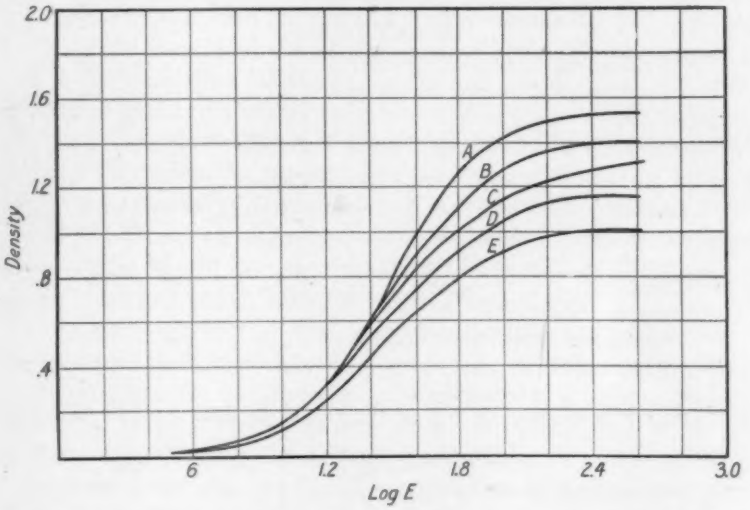
3. Observations have been made relative to the staining of

the deposit and of the gelatine resulting from the action of the reducer and its reaction products, and a means of removing the stain in most cases has been found.

4. The character of the action of a given reducer on negatives cannot, in all cases, be taken as indicative of what its action on prints will be.

5. Reducing solutions made up according to the formulæ appended to this report have been found to give satisfactory action on printing-out papers, the particular one to be chosen in any case

FIG. 10.



depending upon the modification which it is desired to make in the print.

FORMULÆ.

Permanganate Reducer.

Potassium Permanganate	.5	gms.
Sulphuric Acid 10 per cent.	25	c.c.
Water	500	c.c.

Dilution for use: 1 part of solution in 13 parts of water.

Belitski's Reducer.

Ferric Chloride, crystals	6.5	gms.
Potassium or Sodium, oxalate	12.5	gms.
Sodium Sulphite	8	gms.
Water	200	c.c.

When ready to use, add to the above 3 gms. of oxalic acid crystals and agitate the solution until it turns green. Pour the supernatant liquid off the crystals and add to this clear solution 50 gms. of sodium thiosulphate. Dilute this solution 3 parts in 11 parts of water for working on prints.

Iodine Cyanide Reducer.

Iodine (10 per cent. sol. in Potassium Iodide)	25 c.c.
Potassium Cyanide 10 per cent. sol.	4 c.c.
Water	400 c.c.

For paper reduction take solution 1 part, water 10 parts.

Farmer's Solution.

Sodium Thiosulphate 20 per cent.	150 c.c.
Potassium Ferricyanide 10 per cent.	51 c.c.

Dilution for print reduction, 1 part in 3 parts water.

Nietz's Proportional Reducer.

Solution A.		
Potassium Permanganate	.125	gms.
Sulphuric Acid 10 per cent.	7.5	c.c.
Water	500	c.c.
Solution B.		
Ammonium Persulphate	12.5	gms.
Water	500	c.c.

For print reduction take 1 part A, 1 part B, and 4 parts of water.

Ammonium Persulphate Reducer.

Ammonium Persulphate	40	gms.
Water	500	c.c.
Sulphuric Acid	.53	c.c.
Sodium Chloride	.4	gms.

Dilution for print reduction: 1 part in 2 parts of water.

ROCHESTER, N. Y.,
December, 1920.

THE THICKNESS OF WET PAINT FILMS.*

BY

A. H. PFUND, Ph.D.

Associate Professor of Physics, Johns Hopkins University.

IN connection with the study of the hiding-power of paints, as revealed by the cryptometer,[1] the need of an instrument for determining the thickness of a single coat of wet paint has made itself felt. The field of application of such an instrument would be wide: (1) knowing the total thickness of layer necessary for complete hiding, a knowledge of the thickness of one coat would make possible a determination of the "number of coats"; (2) exposure tests could be carried out on paint or varnish films of known thickness; (3) the shrinkage of paint films upon drying could be studied; (4) when the air-brush is used, the thickness of coating might be controlled; (5) the hiding-powers of paints, such as "flat whites" and cold-water paints, which experience a marked change upon drying, might be determined; (6) the skill of a painter in applying uniform coats could be put to a severe test.

The usual method of evaluating the thickness of a wet paint-film involves the rather laborious procedure of determining, first, the specific gravity of the paint. Subsequently, a known area of plate-glass is coated with paint. The can, brush and paint are weighed to an accuracy of 0.01 gr. both before and after painting so as to yield the mass of the paint applied. A simple calculation yields the average thickness of the paint-film. Aside from the length of time involved in carrying out such a determination, the principal objection to this method is that it cannot be used if the constitution (and hence, the specific gravity) of the paint is unknown. Furthermore, the method cannot be used in checking up the actual performance of a painter.

These difficulties are overcome in the instrument about to be described. Advantage is taken of the circumstance that paint is a plastic solid,[2] whose "yield-value" is greater than the capillary forces introduced through the use of the instrument. The prin-

* Communicated by the Author.

[1] Pfund: JOUR. FRANKLIN INST., Nov., 1919, p. 575.

[2] Bingham and Green: *Proc. Am. Soc. Test. Mats.*, Vol. xix, Part ii (1919).

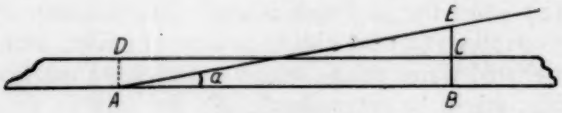
ciple may be illustrated most simply by considering a uniform layer of paint upon which a glass plate, with one edge slightly raised, is placed. As shown diagrammatically in Fig. 1, the volume of paint, originally in the layer *ABCDA*, is crowded into the wedge form *ABEA*. Since the wedge-angle (α) is very small, the thickness (t) of the original film is given by the relation:

$$t = \frac{1}{2}\alpha L$$

where L is the length of the wedge wet by the paint, *i.e.*, the distance AE in Fig. 1.

Since the wedge calls for essentially plane surfaces to which the paint is applied, and since, furthermore, some of the paint is squeezed out from underneath the wedge, a symmetrical wedge was chosen. This is simply a convex, spherical surface which is forced

FIG. 1.



through the paint layer. As shown in Fig. 2, the volume of paint originally in the layer *ABCKA* is forced into the meniscus *AEFGBA*. If the diameter (D) of the circular paint-spot be measured, and if the radius of curvature (R) of the convex surface be known, then, by performing a simple integration, it is found that the thickness (t) of the original paint-film is given by the relation:

$$t = \frac{D^2}{16R}$$

The final form given the instrument is shown in Fig. 3. A convex lens L whose lower surface has a radius of curvature of 25 cm. is mounted in a short tube T, which slides freely in an outer tube T_2. The compression springs S keep the convex surface out of contact with the paint-film until pressure is applied to the top of T_1. This instrument, which is to be designated as the "Paint-film Gauge," is simply rested on a painted surface, and the lens is forced down as far as it will go. Upon releasing the pressure before removing the gauge, a circular spot is left on the gauge as well as on the painted surface. The diameter of the spot on the gauge is measured to 0.1 of a millimetre. If the spot is elliptical,

the mean of the major and minor axes is determined. A series of readings on at least ten spots, judiciously distributed over a given area, yields a fair value of the average thickness of film. By referring to the table printed below, the thickness of the paint-film in mm. and the number of square feet which would be covered by one gallon of paint may be evaluated at once.

d = Diameter of paint spot on lens (in mm.).
t = Thickness of paint film (in mm.).

d In mm.	t Thickness in mm.	Sq. ft. per gal.
3	.00225	18,088
4	.00400	10,175
5	.00625	6,512
6	.00900	4,522
7	.01225	3,321
8	.01600	2,543
9	.02025	2,009
10	.02500	1,628
11	.03025	1,345
12	.03600	1,130
13	.04225	963
14	.04900	830
15	.05625	723
16	.06400	636
17	.07225	563
18	.08100	502
19	.09025	450
20	.10000	407
21	.11025	369
22	.12100	336
23	.13225	307
24	.14400	282
25	.15625	260
26	.16900	241
27	.18225	223
28	.19600	207
29	.21025	193
30	.22500	180
32	.25600	158
34	.28900	141
36	.32400	125
38	.36100	113

A number of experiments were carried out to check the accuracy of the paint-film gauge. In each case a known mass of paint was spread uniformly over a definite area of plate-glass, and the

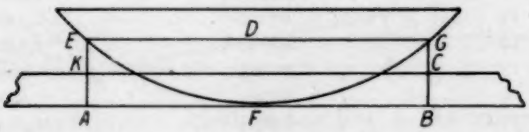
thickness of film was calculated in the usual manner. Different gauges and thickness of layer were used. The results are briefly presented in the following table:

	I	II	III	IV
Film thickness (by calculation)	0.0444 mm.	0.0402	0.0644	0.0638
Film thickness (by Paint-film Gauge) ..	0.0448	0.0390	0.0652	0.0638

Considering the roughness of the measurements, the agreement is surprisingly good. Equally satisfactory results were obtained on varnish films. The differences between the two sets of measurements rarely exceeded 3 per cent.

Having established the reliability of this instrument, it was sought next to determine whether or not different paints had different spreading rates. While it is obvious that a gallon of paint containing much turpentine and other "thinners" will be spread over a much larger area than an equal volume of a thick, creamy

FIG. 2.



paint, it seemed worth while to test the performance of various painters with the same kind of paint. Accordingly, three different kinds of paint were prepared and each painter applied these to a clap-board panel whose surface had been previously primed so as to be impervious to the layer applied. The panel stood in an essentially vertical position, and each painter was asked to apply a characteristic "second coat." The results obtained are shown in the following table:

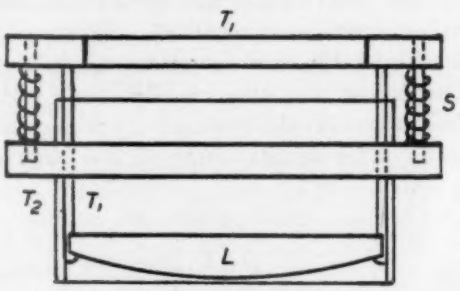
Character of paint		Hiding power	Spreading-rate			
			Painter A	Painter B	Painter C	Painter D
No. 1.	Lithopone, Zinc oxide } 61.5 per cent. Linseed oil 35 per cent.	230 *sq. ft.* gal.	637 *sq. ft.* gal.	601	601	870
No. 2.	Zinc oxide, White lead } 63 per cent. Linseed oil, 37 per cent.	232 *sq. ft.* gal.	580 *sq. ft.* gal.	730	630	790
No. 3.	White lead, 78 per cent. Linseed oil, 22 per cent.	276 *sq. ft.* gal.	434 *sq. ft.* gal.	710	790	830

Painter A finds a maximum spreading rate for paint No. 1, B for paint No. 2, and C for paint No. 3.

The paints were designated as having respectively " no tooth," " medium tooth " and " much tooth." Whether or not these characteristics affect the spreading-rate, seems uncertain from the above results. While, very probably, a theoretical value of spreading-rate might be obtained through the use of the plastometer,[3] it seems clear, that, in practice, greater differences exist between individual painters than between paints. While hiding-power and color are definite characteristics of a paint, the spreading-rate depends very largely upon the painter and is, therefore, in practice a variable quantity.

The shrinkage of wet paint-films may be determined readily

FIG. 3.



by measuring the thickness of the wet film by means of the Paint-film Gauge and that of the dry film by means of a micrometer. While a detailed study of this problem is of interest, it was deemed of less immediate importance than the one dealing with the effect of shrinkage on hiding-power, particularly for those paints which become much brighter upon drying. This problem was attacked by coating a piece of plate-glass (11 x 13 cm.) with a flat-white paint upon which black spots, irregularly spaced, were marked. The entire surface was given a heavy coating of varnish, which was sandpapered smooth when dry. A metallic strip, 0.3 mm. thick, was glued to this surface at the edge of the plate, so that when a pool of paint was poured on the plate, it could be given a wedge-shaped form by leveling off the surface with a straight-edge (steel rule). The thickness of the wedge would obviously

[3] Bingham and Green: *Loc. cit.*

vary from zero to 0.3 mm. While the paint is wet, record is taken of the position of the last spot visible and the film-thickness adjacent to this spot is determined with the Paint-Film Gauge. These data yield the hiding-power of the wet paint. Several other measurements of thickness at various distances from the metal strip are made so as to obtain a relation between film thickness and distance from metallic strip. When the paint is dry, the last spot visible is again sought, and the thickness of the *wet* paint-film, formerly overlying this spot is calculated. This, of course, yields the hiding-power of the *dry* paint. While this mode of procedure is less accurate than that resulting from the use of the cryptometer, it nevertheless makes possible a determination of hiding-power to an accuracy of 5–10 per cent. and solves a type of problem to which the cryptometer cannot be applied.

For lack of time, such numerical determinations were not made —only qualitative results were recorded. Separate strips of glass were also coated with the various paints which were tested for shrinkage. The drying was done rapidly over a radiator. Measurements of brightness on the wet and dry films were made with the Colorimeter.[4] The results obtained are shown in the following table:

Paint	Shrinkage	Brightness increase upon drying	Change in hiding-power upon drying
	Per cent.	Per cent.	
Commercial cold water paint	30	25	Very great increase
Zn O, turpentine	20	10	Marked increase
Zn O, gelatine water	40	5	Slight increase
Zn O, varnish	46	0	No change
Zn O, linseed oil. Drier	12	−1	No change
Commercial flat wall-finish	36	−5	Slight decrease

In spite of large variations in shrinkage values, the hiding-power does not vary with shrinkage but with brightness changes. This conclusion applies only in case that no chemical changes, producing a darkening of the paint-film, set in during the process of drying. In the majority of the above paints, the drying simply involves the evaporating of a fluid. If air-pockets are left, an increase in brightness results because of the smaller refractive

[4] Pfund: JOUR. FRANKLIN INST., March, 1920, p. 371.

index of air. While shrinkage undoubtedly has some effect, its influence is entirely overshadowed by the changes in brightness.

SUMMARY.

1. A new instrument, the Paint-Film Gauge, has been devised to measure the thickness of wet paint-films. The attainable accuracy is better than 3 per cent.

2. The spreading-rates of different types of paints were determined by means of the Paint-Film Gauge. Variations introduced by the painters are greater than those introduced by the paints. In actual practice, spreading-rate is not a constant for a given type of paint.

3. Hiding-powers of paints, in particular those which become markedly brighter upon drying—increase as brightness increases and are but little affected by shrinkage of the paint-film.

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Properties of Gallium.—THEODORE W. RICHARDS and SYLVESTER BOYER, of Harvard University, have made a research on the properties of the metallic element gallium (*Journal of the American Chemical Society*, 1921, xliii, 274–294). Gallium apparently lies between indium and zinc in the electrochemical series, and may be precipitated from weakly acid solutions if sufficient current density be employed. After preliminary purification by electrolysis, gallium may be rendered free from zinc by ignition in a high vacuum or by crystallization; a product of constant melting point is thereby obtained. The melting point of the metal is 29.75° C. on the hydrogen scale. The density of solid gallium is 5.904, that of liquid gallium 6.095, both determinations being made at the melting point. On solidification, gallium undergoes an expansion of 0.00531 c.c. per gram. The solid element has a cubic coefficient of expansion of approximately 0.000055; therefore the density of the solid at 20° C. is 5.907, and the atomic volume of the element is 11.85. The compressibility of solid gallium is 0.0000020; the compressibility of liquid gallium is approximately twice that of the solid. The surface tension of liquid gallium, measured in an atmosphere of carbon dioxide at a temperature of 30° C., is 36.54 milligrams per mm. The latent heat of fusion of gallium is 19.04 calories per gram at a pressure of 173 megabars (approximately 170.75 atmospheres); and the melting point is depressed 0.00207° C. by an increase of one atmosphere in pressure.

J. S. H.

New Reagent for Sugar Analysis.—When a solution contains both glucose and lactose or milk sugar, the amount of each of these sugars present in the solution may be calculated, if the solution be titrated against Fehling's solution both before and after hydrolysis of the lactose. However, since prolonged boiling with an acid is required to hydrolyze lactose completely, mineral acids cannot be used for this purpose, for they further decompose the products of hydrolysis during the prolonged boiling. The new reagent, which has been used with success by E. HILDT (*Ann. Chimie anal. et appl.*, 1920 (2), ii, 78–80) to produce this hydrolysis, is benzenesulphonic acid, obtained by the reaction of sulphuric acid and sodium benezenesulphonate. To hydrolyze the lactose completely, the solution, containing not more than 1 per cent. of sugar and sufficient benzenesulphonic acid to render the concentration of the latter one-fifth normal, is kept for six hours at a temperature of 95° to 98° C.

J. S. H.

Railroad Reconstruction in France. (Information from *French Commission in the United States*, March 7, 1921.)—The following details of the condition of the French railroads and their reconstruction since the Armistice demonstrate the rapidity with which France has recovered from the effects of the war. Of the 2404 kilometers of double track line totally destroyed during the war, all have been completely reconstructed. To permit normal traffic along these lines, it was necessary to wholly rebuild 1400 signal towers, culverts and small bridges of the total of 1503 destroyed. In addition, of the 2785 kilometers of single track line destroyed, 1810 have been entirely reconstructed and opened to traffic. Work on the remaining 975 kilometers is at present being carried out, but is progressing more slowly because double track line is being built instead of the single track line.

The number of locomotives in France at the signing of the Armistice in service was 14,537. On December 31, 1920, this number had increased to 18,429, of which 14,827 were French, 1679 German, 1299 of the Pershing type, and 624 of the American Government type. Orders for 1200 locomotives are at present being carried out. The number of freight cars at the disposal of the French railroads in November, 1918, totaled 410,308. On the 31st of December, 1920, this number had increased to 518,810, of which 432,038 were French, 48,891 German, 18,194 of the Pershing type, and 19,687 American Government type. Work is at present being carried out on 2500 freight cars for various roads.

The figures for the railroads of Alsace-Lorraine are not included in the above total. These railroads have at their disposal 1566 locomotives and 42,297 freight cars. They are to receive from Germany under the terms of the Peace Treaty a further 289 locomotives and 10,000 freight cars.

THE VECTOR SLIDE-RULE.*

BY

A. F. ZAHM, Ph.D.

Bureau of Construction and Repair, U.S.N.

Preface.—In uniplanar analysis one often has to find the magnitude and line of a vector when given its components and its moment about a point. For example, from the lift and drag of an ærofoil and its moment about a pivot one may have to plot the resultant force upon the ærofoil profile. This can be done expeditiously with the slide-rule here described. Also the moment of the vector about another point, and its shift with changing incidence of the ærofoil, can be read on the rule.

Description of the Instrument.—The vector slide-rule, as shown in Fig. 1, comprises a straight scale, preferably transparent, pivoted on a sheet of cross-section paper, and bearing a small slide like a T-square. A fine line is drawn centrally on the bottom of the ruler and passing through the pivot axis; and a like line is drawn on the blade of the T-square. The paper has at least two scales; a circular one about the pivot, and a linear one on a base line through the pivot lengthwise of the sheet. Others can be added to facilitate reading. The large circle shown is used for greater precision in reading small angles.

Magnitude and Direction of the Resultant.—To find the magnitude $\sqrt{L^2 + D^2}$, of the resultant R of the lift L and drag D, rotate the ruler till its centre line passes through the point L, D, and read the value on the ruler scale; to find the direction of the resultant, that is the angle γ whose tangent is D/L, read where the centre line crosses the graduated circle.

Line of the Resultant.—To draw the resultant on a profile page of the ærofoil, when the moment M is known, press the given centre of moments for the profile upon the steel pivot under the rule, and orient the page as shown in the photograph; set the rule at the angle $\gamma - i$ to the base line, where i is the angle of attack; set the edge of the slide at the distance M/R, and it will coincide with the desired line of the resultant R, as seen in the photograph. This R, it will be observed, is normal to the one mentioned in the preceding article; because the ruler was first used to compute R,

* Communicated by the Author.

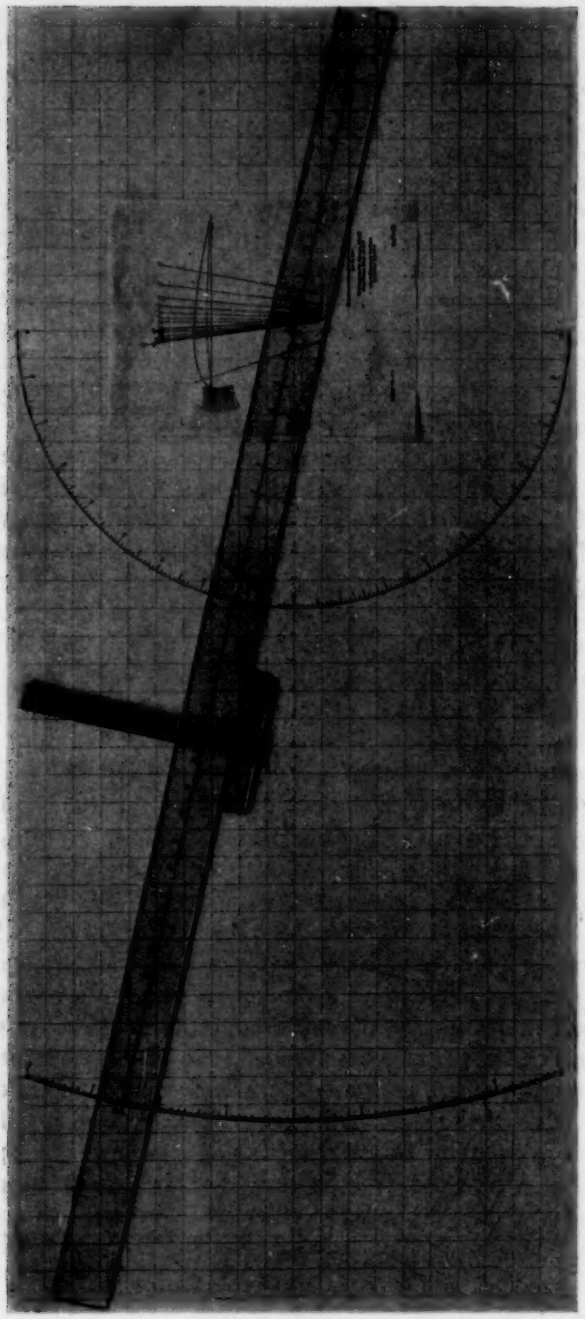


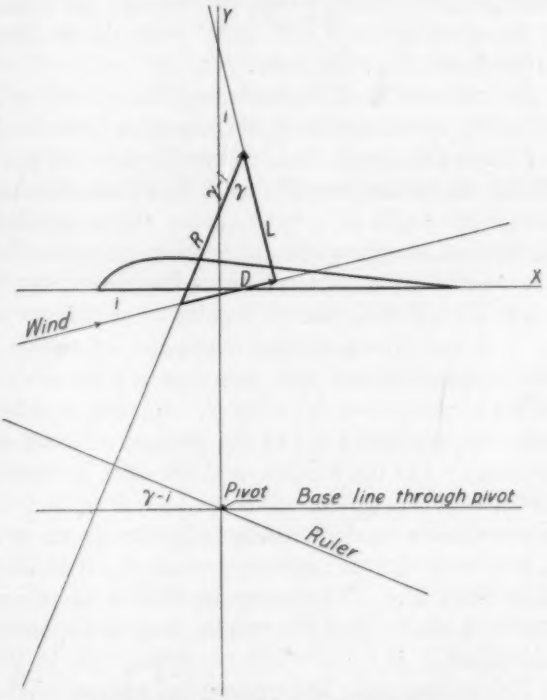
FIG. 1. The Vector slide-rule.

then to guide the T-square slide in drawing R in a more convenient orientation.

Should the profile diagram be n times the size of the ærofoil section, $n\,M/R$ may be used with the same ruler scale, or M/R may be used with a special n-fold scale on the ruler.

Centre of Pressure.—The centre of pressure travel along the chord can, if the page is transparent, be read directly on the under-

FIG. 2.



Slope of ruler when T-square is parallel to R.

neath section paper, at the points where the vector R crosses the chord, allowance being made for n. Also perpendiculars erected at those points, by aid of the slide and an incidence scale on it, have their tops on the centre of pressure curve, which can be drawn on the same page or on a superposed transparent one.

Moment About Any Point.—The moment arm 1, about any other point than the pivot can, when R is drawn, be read directly on the centre-line scale as the distance of said new point from the slide, with due allowance for n. Then $R1$ is the moment.

Multiplication and Division.—To find the quotient $D/L = x$ of any two quantities, lay the centre-line of the rule through the point L, D, and read where it crosses a perpendicular to the base line at any decimal distance, such as 1, 10. For obviously $D/L = x/1$ or $10x/10$. To multiply D by L reverse this process.

Alternative Designs.—The ruler may slide over a circular guide having its centre at the pivot, and carry a try-square slide, thus leaving out the pivot and that part of the ruler which covers its immediate neighborhood, where the vectors are massed. But sometimes the given pivot is well away from the ærofoil, so that the vectors need not cross the ruler.

Again the farther end of the ruler may have crossing it a circular arc with a slide which can be set at the angle i from the base-line, that is $\gamma - i$ from the centre line. Then to draw R the whole is rotated till this slide coincides with the base line, thus setting the ruler at the proper angle $\gamma - i$ to the base. Substantially such an instrument, known as a propeller slide-rule, was described in the JOURNAL OF THE FRANKLIN INSTITUTE for November, 1917.

Geometric Proof.—If the foregoing operations have any novelty, it is in the structure and manipulation rather than the principle of the instrument. Still one may explain why the ruler is set at the angle $\gamma - i$ when drawing R. As seen in Fig. 2, R inclines γ to the lift, and the lift i to the vertical. Hence R and the T-square incline $\gamma - i$ to the vertical, and the ruler inclines the same to the horizontal.

Precision.—Easily made formulas give the above values more accurately, and nomograms accurately enough. Still instruments are needed to draw R. The present method is as precise as the draughtsman can see to plot the results, and is expeditious with little mental effort.

Use as Trigonometer.—The present instrument obviously can be used as an ordinary trigonometer for the solution of plane right triangles. That is if any two of the five elements—the sides and acute angles—be given, the remaining three can be read on the scales. The addition of a second ruler suitably placed would adapt the instrument to the solution of oblique triangles, as shown in the present writer's article, "Steering Aircraft at Sea," in the *Scientific American* for July 25, 1914. The reader may also refer to Appleton's Dictionary for a sketch of a plane trigonometer having a rectangular base sheet with angle scale about its sides, and a ruler pivoted at one corner.

NOTES FROM THE U. S. BUREAU OF STANDARDS.*

PROGRESS REPORT OF THE NATIONAL SCREW THREAD COMMISSION.[1]

(Authorized by Congress, July 18, 1918, H. R. 10852.)
As approved June 19, 1920.

[ABSTRACT.]

IN the Progress Report of the National Screw Thread Commission the following fundamentals have been established:

1. Definitions of screw-thread elements and all terms entering into screw-thread standardization.

2. A standard thread form. Thread angle = 60°; flat at crest = 1/8 pitch.

3. An adequate system of screw threads, consisting of a coarse-thread series and a fine-thread series.

4. Four kinds or classes of fit, with allowances and tolerances for three of the four classes established.

5. An adequate gauging system for inspecting the manufactured product.

The definitions adopted are in accordance with the best American usage.

The thread form adopted is the so-called U. S. or Sellers form, which is in nearly universal use in this country and is much used in other countries.

In the thread system adopted, the coarse-thread series comprises the so-called U. S. series of pitches and diameters, supplemented below one-quarter inch by the A.S.M.E. special machine screws. The fine-thread series comprises the S.A.E. diameters and pitches supplemented below one-quarter inch by the A.S.M.E. regular machine screws.

The four classes of fit adopted are: Class I, Loose fit; Class II, Medium fit; Class III, Close fit, and Class IV, Wrench fit.

Class I is intended for the roughest kind of bolts and nuts, where a very free fit is desired and a certain amount of shake or play is not objectionable.

* Communicated by the Director.

[1] Miscellaneous Publications No. 42.

Class II is subdivided into II-A regular and II-B special. II-A is intended for the ordinary grade of machine work, where a good fit and strict interchangeability are demanded. This class of fit is intended to cover the great bulk of good grade machine work. Class II-B is intended for the highest grade of automobile and aircraft work.

Class III is intended for a very accurate precision fit. This class of work will require specially selected tools and equipment, and possibly some selection of parts in assembly.

Class IV is intended for work to be assembled with a wrench, or to be permanently set, as in the case of engine studs. The Commission was not in possession of sufficient data for the establishment of allowances and tolerances for this class of fit.

The above four classes of fit are arrived at on the basis of a uniform minimum nut for all fits. That is, the minimum nut is the same for all fits, and the necessary difference in dimensions of screw and nut in order to secure the desired looseness or tightness is obtained by changes in the diameter of the screw. This method of standardization reduces to a minimum the number of tap drills, taps, and gauges necessary to produce interchangeable work.

The gauging system adopted insures strict interchangeability in the finished product. This is accomplished by setting up, at the maximum and minimum size of each part, a dead line over which the dimensions must never pass.

The report has been more fully abstracted in *Mechanical Engineering* (Journal of A.S.M.E.), June, 1920; *Machinery*, July, 1920, with certain corrections in the August number; *American Machinist*, September 9 and 16, 1920, and is given in full in the official report.

PYROMETRIC PRACTICE.[2]

By Paul D. Foote, C. O. Fairchild and T. R. Harrison.

[ABSTRACT.]

IN the preparation of this volume the primary object has been to present information which is useful in the choice and operation of pyrometric installations. Enough of the underlying theory

[2] Technologic Paper No. 170.

has been included to make the principle of operation of each type of instrument readily understood.

Special stress is laid upon refinements of construction and installation and precautions for operation, many of which are easily overlooked with the result that serious errors may be introduced.

The working temperature scale is reproduced in different ranges by different types of thermometer or pyrometer, and statements are made as to the agreement between the scales of these instruments and the thermodynamic scale, which is known as the ideal temperature scale. The freezing and boiling points of pure materials are used in calibrating the instruments.

In the section on high-temperature thermometry consideration is given to mercury thermometers when used without protection and also when mounted in metal protecting cases for industrial purposes. Indicating and recording instruments operated by vapor, gas, or liquid pressure and those operated by bimetallic springs or the differential expansion of graphite and metal are considered.

Several types of thermocouples are described which are suited to different ranges of temperature and conditions of use.

Thermoelectric indicating instruments are of three general types: those operating upon the galvanometric principle, those operating upon the potentiometric principle, and those operating upon a combination of these two principles. A galvanometric instrument is subject to errors due to changes in resistance of the leads and thermocouple. A number of different devices are discussed for minimizing or avoiding such errors.

The potentiometric principle is capable of much higher precision than is the galvanometric principle and must be employed where highest refinement is necessary. The fact that the principle is capable of higher precision, however, by no means indicates that it always renders higher precision. The performance depends upon the design and construction of the individual instrument.

The deflection potentiometer combines the rapidity of the galvanometer with the precision of the potentiometer. The gain in rapidity increases as the range of the galvanometer is made nearer to the full range of the complete instrument, while the precision of which the method is capable, decreases accordingly.

The e.m.f. developed by a thermocouple depends upon the

temperature of the cold junctions as well as that of the hot junctions, hence the cold junctions must be maintained at a fixed temperature or some correction method must be adopted in order that the hot-junction temperature may be determined. To avoid the necessity of applying a correction to each reading, a number of automatic or manually operated cold-junction compensating devices have been developed.

In order that thermocouples be interchangeable, thus permitting necessary renewal of worn-out couples, all couples of a given type should have uniform thermoelectric properties. Where this has been impossible, a number of devices have been resorted to with a view to making the couples interchangeable. Many of these devices might easily cause greater errors than would be caused by using the couples without the devices. However, experience in manufacture is rapidly eliminating the necessity of any such arrangement.

Many industrial plants are equipped with large thermoelectric installations, which may include indicators, recorders, temperature control devices or automatic signaling apparatus. For good service a high grade of material and construction is required. The method of connecting several thermocouples to a common return wire is subject to large errors, and its use is seldom or never justified. Many wiring diagrams of typical installations are shown. In some wiring systems recorders are arranged to be connected to successive couples, and means is provided for connecting an indicator to any one of the couples at will. If the recorder and indicator are of the galvanometric type and the instruments read correctly when connected singly, the readings will be in error when the instruments are connected to the same couple at the same time. This error is small with low-resistance couples and leads connected to high-resistance galvanometers.

Compensating leads are often used to extend the cold junctions of couples to a point having approximately constant temperature or to a cold-junction compensator. The zone box and junction box effect a saving in the expensive compensating lead wires in the cases of single couples and multiple installations respectively. If a buried cold junction is used, its temperature should be determined at different seasons of the year.

The depth of immersion of a couple in a furnace is a matter of importance. Often a couple is purposely insufficiently im-

mersed in order that its readings may be proportional to the temperature under consideration without the couple being subjected to the extreme temperature of the inside of the furnace.

It is rarely the case that a thermocouple can be used without protection. The limitations of the protecting tube more often than of the thermocouple, govern the usefulness of thermoelectric pyrometry. Various protecting tubes are described.

Optical pyrometers make use of the intensity of the radiation within a narrow band of the visible spectrum which is emitted by the body whose temperature is to be measured. This intensity varies not only with the temperature but also with the emissive power of the substance.

Optical pyrometers are calibrated to read the temperature of a black body. Fortunately many substances and the inside of furnaces usually require little or no corrections for departure from ideal black-body conditions. For other substances and conditions corrections must be applied.

For very high temperatures the intensity of radiation is reduced by an absorption glass. Tables of emissivity and true temperatures versus observed temperature for a number of substances are given in the text.

Radiation pyrometry differs from optical pyrometry in that the total radiation coming from a body is made use of. It is subject to the effect of emissive power and also requires a number of precautions which are not necessary in optical pyrometry. Radiation pyrometers may be made recording, however, while no recording optical pyrometer has yet been produced.

Resistance pyrometers are often used in certain classes of industrial work. Platinum wire is decidedly the most desirable material to use as the thermometer bulb, though nickel is employed to some extent in the industries, especially below 300°C. Several designs of measuring instruments are described, as are different methods of connecting to the bulb for the purpose of minimizing or eliminating errors due to lead resistance and to resistance at dial contacts within the instrument. These instruments may also be made of the deflection type and as recorders.

Through the use of recording pyrometers much valuable information may be obtained which leads to improved processes, increased uniformity and quality of product, reduction of cost of production, etc. The leading recording instruments are shown in

cuts and described in detail in the chapter on recording pyrometry.

Transformation-point indicators and recorders are treated at some length, along with different methods of interpreting the data.

The meaning of temperature control may be extended to cover not only the control of temperatures but also the control of processes through a knowledge of the temperatures involved. In this sense it has a very wide interest. This section is not confined to a description of the apparatus used but enters into this broader phase of the subject.

The subject of melting-point methods is treated at length. The general classes of substances considered under this heading are metals, alloys, salts, and refractory materials, and for the temperature measurements, thermoelectric resistance, and optical pyrometers are discussed. Where substances of known melting points are employed, the methods are equally applicable to the calibration of the pyrometers being used. Tables of melting points are given.

Detailed information is presented as to the most suitable type of pyrometer to be used, the proper crucible and atmosphere for many materials, and suitable furnaces for different classes of work.

Complete information is given for the calibration of all of the important high-temperature measuring instruments which are used industrially, and suitable apparatus and accessories are described for each type of calibration. High-temperature thermometers may be calibrated by immersion in vapors of various boiling liquids or by the more convenient comparison method. Suitable comparators and others details are considered.

Thermocouple calibrations are either primary, where the melting points of several metals are used, or secondary, where comparison is made with other couples. All thermocouples should be annealed before testing. Homogeneity tests are also often necessary.

Beside the ordinary primary and secondary calibrations, numerous methods are described for checking thermocouples at only one or two points. The method is described for welding thermocouple junctions. The method of calculation of cold-junction corrections is also explained. Many measuring instruments for thermocouples are equipped with cold-junction compensators. This is often very desirable, but unless certain

precautions are taken errors are likely to be introduced when standardized thermocouples are used with such instruments, or when these instruments are calibrated alone or in conjunction with thermocouples. Proper methods of procedure to avoid such errors are considered in detail.

Optical pyrometers are usually calibrated by the secondary method, where the pyrometer under tests is compared with an instrument which has been accurately calibrated. A precise and satisfactory primary calibration requires considerable technique and is not necessary except for special research work in the laboratory when the highest possible precision is required. Methods for both primary and secondary standardizations are considered.

For precision work radiation pyrometers must be standardized and used with extreme care. It has been found that many of the instruments are subject to peculiar errors requiring for their elimination rigid specifications in the method of calibration and use.

Primary calibrations are made by sighting into a specially designed "black-body" furnace, the temperature of which is measured by thermocouples. Secondary calibrations are made by sighting the instrument to be tested and a standardized instrument on the same source.

If an accurately calibrated resistance-measuring instrument is employed, the most precise method of standardizing a pure platinum resistance thermometer is by observations of the resistance at the temperatures of melting ice, steam, and sulphur vapor. A thermometer thus calibrated defines the temperature scale in the range where temperatures are most accurately known. Thermometers with indicators may be calibrated by secondary methods.

In the section on industrial applications of pyrometry no attempt is made to give all the applications. In fact many of the most important applications are omitted. The object of the section is to consider some of the applications which offer peculiar difficulties.

In this connection are treated the applications of pyrometry to glass manufacture, glass annealing, rotary Portland cement kilns, ceramic processes, coke manufacture, and steel manufacture. In an appendix are given conversion tables from Fahrenheit to Centigrade and vice versa, and other useful data.

THE TESTING OF PAPER.[3]

[ABSTRACT.]

THIS circular is published to meet the requests for information in regard to the testing of papers, since the interest in this subject is steadily increasing.

It contains information relating to the methods of testing paper and the apparatus employed in the paper laboratories of the Bureau of Standards for the routine testing of paper. The introduction discusses the size and importance of the paper industry and briefly considers the various fibrous raw materials for paper manufacture. Grasses and crop plants are referred to, and it is brought out that their use on a commercial scale is largely dependent on the cost of production. A rough classification is made of paper; it is divided into (1) boards, (2) building, (3) blotting, (4) book and cover, (5) news and hanging, (6) tissue, (7) wrapping, (8) fine (writing, bond, etc.), and (9) specialties. Paper is defined as a matted or felted structure of fibrous material, formed into a relatively thin sheet.

The value of paper testing is brought out, and it is emphasized that different testing methods are necessary for paper for different uses. By this is meant that, for instance, different kinds of physical tests are necessary for different types of paper, such as tissue and wallboard. For wrappers and envelopes, a tearing test is desirable, since such papers should be made to withstand a strain applied in that manner. A brief summary is given of suggested methods of developing specifications for paper. These suggestions are broad in scope and must be somewhat modified to meet particular conditions.

The physical qualities of paper are affected by changes of temperature and humidity, and a testing room with constant conditions of 70° F. temperature and 65 per cent. relative humidity is used. The degree of change due to atmospheric changes has not yet been worked out. A convenient form of rack for conditioning paper is illustrated. The following methods of testing the physical qualities of paper are given in detail with illustrations: weight, thickness, bursting strength, tensile strength, folding endurance, tearing strength, absorption, and transparency. These methods are so given that they may be of use in any laboratory

[3] Circular No. 107.

testing papers. The accuracy of some of the methods is given, and it is emphasized that at least ten tests should be made and an average obtained.

Under chemical testing are given the methods of determining the percentage of ash in paper and the amount of sizing. Two methods are given for the quantitative determination of rosin in paper, one of which is quicker but not so accurate, yet useful for control work. Qualitative tests for the various kinds of loading material are outlined. Qualitative tests for various sizing materials, such as rosin, starch, and glue are also given.

In regard to the microscopical examination and estimation of the fibres of which paper is made, the procedure is given in detail. The formula for the zinc-chloride iodine stain is given, and recommendations are made as to its use. It is almost impossible to describe this method, since much experience is necessary before accurate determinations can be made. The estimation method, with the use of standard mixtures carefully made up, is strongly recommended for speed and accuracy for routine testing. Several microphotographs illustrate representative wood fibres and show how the markings and shapes can be easily studied.

A working bibliography of useful books, periodicals, and government publications is included, but no attempt is made to make it complete. Recommendations are made as to size of sample to submit for test, and a fee schedule is given. The importance of proper sampling of paper is emphasized and instructions given as to recommended methods.

SAND-LIME BRICK—DESCRIPTION AND SPECIFICATION.[4]

[ABSTRACT.]

SAND-LIME brick is a building brick made of sand and lime. It was first produced in the United States in 1901. By the action of steam under pressure, the lime is caused to combine with some of the sand, forming a hydrated calcium silicate. This material acts as a bonding agent to hold the rest of the sand together. Most sand-lime bricks will compare favorably with "first common" clay bricks. They are characterized by their straight edges, parallel faces, and nearly white color. Their continued use in

[4] Circular No. 109.

Northern climates has established their durability under weather conditions, but sand-lime brick is not a refractory material. The industry maintains a national association with which the Bureau coöperates in conducting research work on the subject. Bureau of Standards Technologic Paper No. 85 contains detailed descriptions of the method of manufacture and of several factories. A good sand-lime brick for general purposes should have an absorption of not over 20 per cent., an average compressive strength of not less than 2000 pounds per square inch, and an average modulus of rupture of not less than 450 pounds per square inch.

COLORED WALL PLASTER.[5]

By W. E. Emley and C. F. Faxon.

[ABSTRACT.]

GYPSUM wood-fibred plaster is a commercial article made of calcined gypsum, wood fibre, and other ingredients. This wood fibre can be dyed with aniline dyes, to produce any desired color, the dyes being fast to light. By the use of dyed wood fibre, a colored gypsum plaster can be made. After this has been applied to the wall and allowed to set, the surfaces may be scrubbed with soap and water, thereby exposing the colored fibres.

Some very beautiful effects may be produced, not only because of the great variety of colors available, but also by the use of fibres of different sizes, by different proportions of fibre and by different surface treatments.

The finished wall may be made artistic because both the color and texture can be controlled. It is in effect a plaster-wall, and should be treated accordingly. It can, however, be scrubbed with soap and water whenever it gets dirty or the colors become dull.

RECENT MODIFICATIONS IN THE CONSTRUCTION OF PLATINUM RESISTANCE THERMOMETERS.[6]

By T. S. Sligh, Jr.

[ABSTRACT.]

THE paper describes some recent modifications in the construction of platinum resistance thermometers which have been

[5] Technologic Paper No. 181.

[6] Scientific Paper No. 407.

found desirable on account of a gain in accuracy, a simplification of construction, or on account of the greater mechanical strength.

All thermometers are of the potential-terminal type, as the use of this type with a potentiometer or a Wheatstone bridge with reversing commutator offers complete elimination of the effects of lead resistance.

Changes in the construction of the strain-free type of thermometer from that described in Bureau of Standards Bulletin No. 6, p. 150, 1909, consist in the sealing of the thermometer tube to prevent condensation of atmospheric moisture in the thermometer at low temperatures, the use of a neater and simpler thermometer head composed of a brass shell with bakelite base and cap, and the use of thermometer leads consisting of a four-strand cable insulated with a double-silk wrapping and a silk braid. Each strand of this cable consists of three No. 28 insulated copper wires twisted together and double-silk covered. The lead terminals are cut and formed from thin sheet copper. This form of thermometer lead possesses sufficient flexibility and is far superior in point of constancy of resistance to the fine-strand lamp-cord leads previously used.

Calorimetric thermometers of the type described in Bureau of Standards Bulletin No. 9, p. 483, 1913, have been found to show a value of the delta (δ) constant in the Callendar difference formula of about $\delta = 1.47$ as against delta value of $\delta = 1.495$ for a strain-free thermometer wound of the same wire. The effect of this difference upon the scale defined by the thermometer in the range 0–100° C. was not sufficiently large to warrant an extended investigation as to the cause of the low value of delta. However, later the commercial type of this thermometer was found to show values of delta as low as $\delta = 1.44$. This fact, together with the desirability of extending the range of the thermometer, led to an investigation which indicated that the low value of delta was due largely to a strained condition of the winding of this type of thermometer.

Strain in the winding may be reduced to a negligible factor by thoroughly annealing the wire before winding the coil, by winding under *very light* tension on a mica core plate not less than 0.5 mm. thick in order to avoid the strain due to bending the wire around sharp corners, by flash-annealing the winding both before and

after placing it in the case, and by avoiding pressures on the sheath large enough to strain or deform the winding.

The flash-annealing is accomplished by repeatedly connecting the winding to a voltage sufficiently great to bring the winding to a temperature of approximately 1000° C. before the mica has time to reach its dehydration temperature (700° C.). This annealing is specially valuable after the sheath has been flattened down on the coil.

The thermometer case which is made of german silver tubing 0.75 cm. in diameter by 0.02 cm. thick with the lower end flattened into a sheath for the winding is much more robust and fully as effective in eliminating the effects of thermal conduction down the leads and the stem as was the original case with a metal sheath and a glass stem. The four centimeters of the internal leads immediately above the winding are flattened and placed between thin strips of mica, upon which the sheath is pressed tightly.

The head and external leads are as described above. The drying-head previously used has been found to be unnecessary where the thermometer case is tight and the initial drying has been complete.

A type of heating coil constructed by winding resistance ribbon on a flat strip of mica, insulating by means of thin mica side plates, and enclosing in a flattened copper tube or sheath, has been found to be very convenient for general laboratory use. Because of the small heat capacity and the large heat transfer coefficient of this heating coil it is specially desirable for use in thermostated water baths and for work involving the measurement of heat energy. The coil will transfer to a bath of stirred water about 0.07 watts/cm^2 per degree of difference of temperature between the winding and the water. Thus a coil 3 cm. wide by 17 cm. long by 0.15 cm. thick will transfer 1000 watts of energy to a water bath at 25 C. with a winding temperature of about 140 C.

NATIONAL ELECTRICAL SAFETY CODE.[1]

[ABSTRACT.]

Handbook No. 3 contains a third edition of the National Electrical Safety Code which was previously issued as Circular 54. The new edition is a book of pocket size, and the discussion of the

[1] Circular No. 3.

rules has been segregated in a separate volume which will appear later as Handbook No. 4.

In addition to two introductory sections giving definitions of terms, and rules for the grounding of apparatus and circuits, the code consists of four principal parts, as follows:

1. Rules for the installation of machinery, switchboards, and wiring in central stations and substations.

2. Rules for the construction of overhead and underground lines for the transmission and distribution of electrical energy and intelligence.

3. Rules for the installation of electrical apparatus and wiring in factories, residences, and wherever electricity is utilized for light, heat, or power.

4. Rules for safeguarding employees when working on or near electrical machines or lines.

The rules of Section 9 specify where to attach the ground conductor, how to run it, how to make connections. It limits the permissible resistance of ground connections and restricts the joint use of ground conductors.

Part 1 contains sections covering the general arrangement of stations and of equipment; rotating equipment; storage batteries; transformers, ground detectors, etc.; conductors; fuses, switches, etc.; switchboards; and lightning arresters.

Part 2 contains sections devoted to the following subjects: scope and general requirements; pole lines in general; clearances; classification of circuits according to the grade of construction required; specifications for strength, etc.; supply lines in general; supply lines crossing railways; supply lines crossing signal lines and joint use of poles; signal lines; underground construction. Appendices to this part contain: a map showing the three loading districts; loading data and tables of sags for overhead conductors; data and tables for determining sizes of poles and guys required, pole setting, etc.

Part 3 contains sections dealing with the following items of utilization equipment: scope and general requirements; conductors; fuses, switches, etc.; switchboards and panel-boards; motors; furnaces, batteries, transformers, and lightning arresters; lighting fixtures and signs; portable devices; cars, cranes, and elevators; telephones and signal apparatus.

Part 4 contains operating rules for both employer and em-

ployee, with separate sections dealing especially with supply stations, supply lines, and telephone and telegraph lines.

This Code has been developed with the coöperation of all interests concerned, including the different classes of utilities, manufacturers, electrical workers, insurance companies, state and city administrative officials. It has been thoroughly revised for this edition, and nearly all of the rules are acceptable to those who must work under them. They have already been made mandatory in a number of states, and their use, no doubt, will be greatly extended now that the new edition is available. They are being used voluntarily by a large number of utility companies.

SPECIFICATIONS FOR MARINE SEXTANTS.[8]

[ABSTRACT.]

These specifications, incorporating standard practice in design and performance of sextants, are the basis for certificates issued by the Bureau of Standards. They cover the rigidity, durability, convenience of operation, and mechanical perfection of the instrument; range and accuracy of the scales; consistent tolerances for the mirrors, shade glasses, and telescopes; and provisions for adjustment and replacements.

New instruments are expected to conform closely with these specifications or represent improvements. The precision required of old instruments is placed somewhat below that required of new in order that those which are still serviceable and reliable may not be excluded from certification.

British Gas Mantle Industry.—According to a statement to the Board of Trade by the Incandescent Mantle Manufacturers' Association (*Journ. Soc. Chem. Ind., Review*, 1921, xl, 39–40), five factories now exist in Great Britain for the manufacture of thorium nitrate, which is used in the mantles, from Indian monazite sand. The capacity for yearly output of gas mantles is now over 130,000,000. It is estimated that 32,000,000 more tons of coal would be required yearly to produce the same illumination, if flat-flame burners were used instead of gas mantles. An adequate supply of benzene, toluene, and related hydrocarbons for the industries can be obtained only by stripping gas; and such stripped gas can be used as an illuminant only in conjunction with gas mantles.

J. S. H.

[8] Circular No. 110.

NOTES FROM THE U. S. BUREAU OF CHEMISTRY.*

STUDIES IN MUSTARD SEEDS AND SUBSTITUTES: I. CHINESE COLZA (*BRASSICA CAMPESTRIS CHINOLEIFERA* VIEHOEVER).[1]

By Arno Viehoever, Joseph F. Clevenger and Clare Olin Ewing.

[ABSTRACT.]

MATERIAL imported as rape seed and sold as mustard seed was identified as Chinese colza, *Brassica campestris chinoleifera* Viehoever, n. var. The characteristics of the seed have been established, and those which permit the identification and differentiation from true mustard seed have been pointed out. Plants have been grown from the seed, and the characters have been established, especially with reference to their close relationship to the colza group, *Brassica campestris.*

The volatile oil obtained from the material was identified as crotonyl isothiocyanate, which is not a suitable substitute for mustard oil, with respect to condimental, bactericidal, or medicinal value. The fixed oil proved to be of the general composition of the rape oils, and the quantity of the oil present, amounting to more than 40 per cent., characterized the seed as a very valuable oil seed.

On the basis of the general composition of the seed and the character of the volatile oil, it is suggested that the pressed oil cake may well be used as a stock feed.

The leaves are succulent and should be of value as greens.

The plants, which are very vigorous and apparently hardy, seem to offer possibilities as a forage crop. Experiments along this line have been undertaken in coöperation with the Bureau of Plant Industry.

CONDENSED DESCRIPTION OF CHINESE COLZA (*BRASSICA CAMPESTRIS CHINOLEIFERA* VIEHOEVER).

Basal or radical leaves first single, later numerous, arranged in clusters, large glossy green, usually smooth, obovate or round, obovate in general outline, entire or obscurely wavy, variously

* Communicated by the Chief of the Bureau.

[1] Published in *Journal of Agricultural Research,* Vol. 20 (1920), No. 2, p. 117.

toothed, sometimes crenate, tapering into a distinct thin petiole, which is more or less margined, showing sometimes a few leaf-like lobes.

Leaves of flowering stem more or less glaucous, clasping, obovate, oblong, or somewhat lanciolate acuminate; leaves of secondary stem not always clasping.

Flowers light yellow, of medium size (generally that of mustard flowers), pedicels averaging well over ½ inch.

Pods rather large and long, tapering into conical beak (0.4 to 0.8 inch long); pod and beak together from 2 to 3 inches long; from 8 to 12 seeds in pod.

Seeds yellow and brown, yellow greatly predominating; somewhat compressed, oval, usually distinct ridge on ventral side, usually smooth brown, slightly reticulated, varying in size (from 1.69 to 2.07 mm.), weighing from 1.4 to 6.4 mgm. (1000 seeds weighed 2.865 gm. and 500 cc. weighed 352 gm.).

Seed Coat.—Epidermis about 5 microns thick; when it is moistened shows no swelling, no polarization of light, or cell structure. Parenchyma almost completely compressed. Sclerenchyma (palisade cells), from 15 to 31 microns high and from 8 to 15 wide, strongly thickened at the base and side, without pigment, inner wall smooth. Pigment layer consists of one row of cells containing pigment only in brown seeds. Protein layer is formed usually by one row of large cells (from 15 to 21 microns high and from 15 to 42 microns wide).

Seed.—Composition averages as follows: Over 40 per cent. fatty oil (colza or rape oil type); about 23 per cent. protein (N = 6.25); 11.5 per cent. reducing substances; 4 per cent. crude fibre; 0.5 per cent. by hydrolysis of volatile oil consisting of crotonyl isothiocyanate.

THE CARE OF LEATHER.[2]

By F. P. Veitch, H. P. Holman and R. W. Frey.

[ABSTRACT.]

DIRECTIONS for the selection of safe, sensible and serviceable boots, shoes, harness, leather belting and other articles, together with detailed advice on the care of leather, are given in Farmers' Bulletin 1183 of the United States Department of Agriculture.

[2] *U. S. Dept. of Agri., Farmers' Bul. 1183,* issued December, 1920.

It is stated that the general application of the directions given will decrease the nation's shoe bills by from 300,000,000 to 250,000,000 pairs and double the average period of serviceability of harness and machine belts. Formulas for water-proofing shoes, worked out in the Bureau of Chemistry and found to be the best of several hundred tried, are given.

A BACTERIOLOGICAL STUDY OF CANNED RIPE OLIVES.[3]

By S. A. Koser.

[ABSTRACT.]

IN the bacteriological examination of 480 commercial containers of ripe olives, living microörganisms were obtained in practically every instance from samples which were abnormal, as indicated by either a swelled condition of the container or a bad odor. Viable microörganisms were found in a small percentage of normal containers. These were either ærobic, spore-forming bacilli, cocci, or apparently dormant members of the colon group. A study of the organisms encountered in the spoiled samples showed a great diversity of types, among which the colon group predominated.

KRYPTOCYANINES. A NEW SERIES OF PHOTOSENSITIZING DYES.[4]

By E. Q. Adams and H. L. Haller.

[ABSTRACT.]

A NEW type of photosensitizing dye having an absorption maximum near 7000 Å and a sensitization maximum near 7400 Å has been prepared in the Color Laboratory of the Bureau of Chemistry. These dyes are formed by the action of alcoholic alkali and formaldehyde (or chloroform) on the alkyl halides (or other quaternary addition compounds) of sufficiently pure lepidine and its homologs. Dyes of the same or similar type are produced under some circumstances in the absence of formaldehyde or chloroform. The name "kryptocyanine" is suggested for these dyes, the structure of which has been tentatively worked out.

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[3] Published in *Journal of Agricultural Research*, Vol. 20 (1920), No. 5, p. 375.

[4] *J. Am. Chem. Soc.*, **42** (1920), 2661.

THE MAINE SARDINE INDUSTRY.[5]

By F. C. Weber.

[ABSTRACT.]

A SPECIAL study was made of the existing methods of canning sardines, special attention being given to the transportation of the fish from the fishing grounds to the canneries, and methods worked out for the improvement of the pack at the various steps of the packing process.

A chemical and bacteriological study of the food of the sea herring from which the Maine sardine is made showed that two organisms, *Bacillus Walfischrauschbrand* and a bacterium designated as *Bacillus B*, are associated with this food. Ammonia and amines were determined as end products of their growth. The difficulty with "swells," experienced by the packer, has been traced to the presence of these bacteria. Suggestions for the prevention of decomposition of the fish have been made.

Many uses for the unavoidable waste, including the preparation of fish meal for animal feeding purposes, are suggested, as well as ways to eliminate the avoidable waste of edible portions of the fish.

It is believed that by heeding the Bureau's suggestions, the Maine sardine packer may greatly improve his output and compete more successfully with the foreign packer. Some of the suggestions have already been adopted by the sardine industry, with gratifying results.

ORANGE VINEGAR—ITS MANUFACTURE AND COMPOSITION.[6]

By H. D. Poore.

[ABSTRACT.]

THE results of experimental work conducted by the Citrus By-Products Laboratory show that there is no reason why orange vinegar, put up in quart bottles under well-established brands, can not compete with the fancy grades of cider vinegars, which retail in quart bottles at from 80 cents to $1.40 a gallon.

Samples of orange vinegar submitted to jobbers making a

[5] *U. S. Dept. Agr. Bull. 908*, issued January, 1921.

[6] Published in *J. Ind. Eng. Chem.*, 12 (1920), 1176.

business of handling vinegar have been pronounced as fine as the best grades of their product. The color, odor, and taste are practically the same as those of apple vinegar, no distinguishing characteristic being noted.

OTOBA BUTTER.[1]

By Walter F. Baughman, George S. Jamieson and Dirk H. Brauns.

[ABSTRACT.]

OTOBA BUTTER, the fat expressed from *Myristica otoba,* has been used for many years by the South Americans as a medicament for skin diseases of domestic animals. A sample from Colombia, South America, has recently been investigated in the Bureau of Chemistry. When received it had a brown color and a disagreeable odor. It was found to contain 9.3 per cent. of essential oil (obtained by steam distillation) with the following characteristics: Specific gravity at 20°C., 0.89067; specific rotation, $[\alpha]_D^{20}$ −32; and refractive index at 20°C., 1.4180. This essential oil appears to be composed of sesquiterpenes. The unsaponifiable constituents other than the essential oil which are present in large amounts are two crystalline isomers, otobite and iso-otobite. The remainder was a very viscous, yellow resin-like mixture which was not further investigated.

Composition of Unsaponifiable Constituents.

Constituent.	Carbon	Hydrogen	Oxygen	Molecular weight	$[\alpha]_D^{20}$	Calculated for $C_{30}H_{20}O_4$		
						C	H	O
	Per cent.	*Per cent.*	*Per cent.*			*Per cent.*	*Per cent.*	*Per cent.*
Otobite ...	74.10	6.19	19.71	310	− 35.7	74.05	6.21	19.74
Iso-otobite.	74.29	6.06	19.64	315	+ 5.3			

These otobites did not give the phytosterol tests. When brominated, both gave penta-bromides. The Zeisel method showed that otobite contained one meth-oxy group, and the iso-otobite, none.

Chemical and Physical Characteristics of the Fat.

Specific gravity, at 20°/20° C.	0.9293
Refractive index at 40° C.	1.4710

[1] Published in *J. Am. Chem. Soc.,* **43** (1921), 199.

Iodin number (Hanus)	54.0
Saponification value	185.0
Melting point (°C.)	34.0
Essential oil (per cent.)	9.3
Unsaponifiable matter (other than essential oil) (per cent.)	20.4
Fatty acids (per cent.)	67.6

Chemical Composition of the Fat.

		Per cent.
Glycerides of	Lauric acid	15.1
	Myristic acid	52.2
	Palmitic acid	0.2
	Oleic acid	3.9
Essential oil		9.3
Unsaponifiable	Otobite, Iso-otobite	9.4
	Viscous resin	11.0

Visibility of the Landscape During Rain.—F. W. PRESTON. (*Nature*, November 11, 1920.)—On a visit to Wales the author "was impressed with the variations in the visibility of the landscape when rain was falling. In the lower valleys a storm which may be sufficient to wet thick clothing through in a few moments may leave the contours of the mountains quite distinct at several miles distance. On the other hand, a mountain drizzle or 'Scotch mist' may render everything invisible at a few yards." Assuming that the atmosphere is perfectly transparent, that the rain-drops are entirely opaque, and that the phenomena of the persistence of vision may be neglected, a simple treatment of the matter is presented which leads to the interesting result that the obscuring power of a storm (the reciprocal of the maximum distance at which objects can be seen through the storm) is directly proportional to the number of drops falling per second on a unit area, and in no way depends on their size. It is also proportional to the coefficient viscosity of the medium in which the drops fall and is inversely proportional to the acceleration of gravity. Thus for two storms exactly alike in all respects, except that one was at the equator and the other at the pole, the obscuring power would be greater at the former place, because there the acceleration due to gravity is less. Objects could be seen at a greater distance through the polar storm. The difference between the obscuring powers of a Scotch mist and of a heavy rain depends upon the vastly greater number of mist droplets sinking across a given horizontal line in a second than is the case with the rain. The author calculates that under his assumptions and taking a rainfall consisting of drops one mm. in diameter and amounting to one cm. per hour, the landscape would be blotted out at a distance of seven km., or 4.5 miles from the observer. G. F. S.

NOTES FROM THE U. S. BUREAU OF MINES.*

WATER-GAS APPARATUS AND CENTRAL DISTRICT COAL AS GENERATOR FUEL.

By William W. Odell.

By reason of the greatly increased cost of the gas oil used to enrich water gas, and the higher costs of coal and labor, many gas companies, especially those having franchises that call for the delivery of gas of a certain quality at a certain price per 1000 feet, are having financial difficulties. Reconstruction of plants to manufacture coal gas instead of water gas is difficult if not economically impossible under present conditions. The situation calls for the use of practical economies and methods. One of these economies is the use of cheaper grades of coal to replace anthracite or coke.

The U. S. Bureau of Mines, in coöperation with the Illinois Geological Survey and the engineering experiment station of the University of Illinois, is investigating the possibilities of substituting Indiana and Illinois coal for coke in water-gas generator sets. The investigation has included a study of present practice in commercial plants, with a view to determining changes needed in equipment, design and operation when burning coal as compared with anthracite or coke. Results of the preliminary studies are presented in Technical Paper 246 of the bureau, entitled, "Water-Gas Apparatus and the Use of Central District Coal as Generator Fuel."

SAYBOLT FUROL VISCOSIMETER.

By E. W. Dean.

As inspection work for the U. S. Shipping Board had impressed on the Bureau of Mines the desirability of defining fuel oil in terms of viscosity rather than gravity, the Bureau secured the coöperation of George M. Saybolt in developing a satisfactory viscosimeter for testing heavy fuel oils. Assistance was also rendered by the Bureau of Standards, and several other organizations interested in fuel testing. The new viscosimeter, which has been

* Communicated by the Director.

named the "Saybolt furol," has been adopted by the U. S. Shipping Board, the Bureau of Mines, and the Committee on Standardization of Petroleum Specifications, as official for testing heavy fuel oils. The instrument has a wide range of applicability in commercial transactions in fuel oil and its use is recommended to buyers and sellers of the more viscous types of residuum products. A report describing the viscosimeter has been issued in mimeographed form.

THIRD SEMI-ANNUAL MOTOR GASOLINE SURVEY.

By N. A. C. Smith.

SURVEYS made by the Bureau of Mines of motor gasoline marketed in 1915, 1917, and 1919, showed that motor gasoline had become notably less volatile during each two-year period. Semi-annual surveys were then instituted to determine whether this change was continuing. The first of these, in January, 1920, showed little change. The second in July, 1920, indicated a marked decrease in volatility, but this was attributed largely to seasonal variation in quality of gasoline manufactured for summer sale as compared with winter. The third survey, in January, 1921, shows the same volatility, but the lower boiling point and higher end point indicate that a large proportion of gasoline is being made by blending casing-head or natural-gas gasoline with naphtha. Results of the last survey have been published in mimeographed form.

Explosives Regulation.—A history of the administration of the Federal Explosives Act of October 6, 1917, recently terminated by Joint Resolution of Congress, is presented in a recent bulletin (No. 198) of the Bureau of Mines, entitled, "Regulation of explosives in the United States, with special reference to the administration of the Explosives Act of October 6, 1917, by the Bureau of Mines," by C. E. Munroe.

THE FRANKLIN INSTITUTE.

(Proceedings of the Stated Meeting held Wednesday, March 16, 1921.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, March 16, 1921.

PRESIDENT DR. WALTON CLARK *in the Chair.*

Additions to membership, since last report, 7.

Reports of progress were presented by the Committee on Library and the Committee on Science and the Arts.

General John J. Pershing was nominated by the Board of Managers to the Institute for honorary membership and the following resolution was unanimously adopted:

> *Resolved*, That the Board of Managers recommend to the Institute the election to Honorary Membership of General John J. Pershing, General of the Armies of the United States, in recognition of his signal success in the use of scientific and technical methods and means in modern warfare.

Mr. Andrew M. Fairlie, Chemical Engineer, of Atlanta, Georgia, was introduced and presented the paper of the evening, entitled "Recent Developments in the Manufacture of Sulphuric Acid." The paper was devoted chiefly to the nitration processes for the manufacture of sulphuric acid. Consideration was given to some of the developments in design and construction of plant as well as developments in operation which have become noteworthy during and since the war. Acid-proof masonry towers, new varieties of tower-packing material, the Mills-Packard water-cooled acid chamber, other recent proposals for removing the heat of the chamber reactions by means of water-cooling, and nitration by means of oxidized ammonia gas were briefly discussed. The subject was illustrated by lantern slides.

The thanks of the meeting were extended to the speaker.

Adjourned.

R. B. OWENS,
Secretary.

COMMITTEE ON SCIENCE AND THE ARTS.

(Abstract of Proceedings of the Stated Meeting held Wednesday, March 2, 1921.)

HALL OF THE INSTITUTE,
PHILADELPHIA, March 2, 1921.

MR. CHARLES W. MASLAND *in the Chair.*

The following report was presented for Final Action:

No. 2750: Tate Electrolytic Waterproofing Process. The Howard N. Potts Gold Medal to Mr. Alfred O. Tate, of New York.

The following report was presented for first reading:

No. 2749: Surface Combustion Burner.

R. B. OWENS,
Secretary.

SECTIONS.

Mechanical and Engineering Section.—A meeting of the Section was held in the Hall of the Institute on Thursday evening, March 3, 1921. The meeting was called to order at 8 o'clock by Dr. Gellert Alleman.

Mr. C. A. Emerson, Jr., Chief, Engineering Division, Department of Health, Commonwealth of Pennsylvania, Harrisburg, Pa., presented a paper on the "Disposal of Industrial Wastes and Stream Pollution." Consideration was given to the engineering aspects of recent developments in methods of treatment of some of the industrial wastes widely distributed throughout Pennsylvania. The possibilities of the prevention of stream pollution and the recovery of by-products were pointed out. The subject was illustrated by lantern slides.

The paper was discussed, a vote of thanks extended to the speaker and the meeting adjourned.

R. B. OWENS,
Secretary.

Section of Physics and Chemistry.—A meeting of the Section was held in the Hall of the Institute on Thursday evening, March 10, 1921, at 8 o'clock, with Mr. Benjamin Franklin in the Chair.

Lafayette B. Mendel, Ph.D., Sc.D., Professor of Physiological Chemistry, Yale University, New Haven, Connecticut, presented the paper of the evening, entitled "Chemical Factors in Nutrition." The speaker reviewed the history of the changing conceptions regarding the rôle of digestion in nutrition and indicated how the newer investigations have contributed to the formulation of present-day views regarding what constitutes a food. Reference was also made to some of the current ideas of metabolism, its relation to the chemical composition of the diet, its variations in health and disease and the limitations of our knowledge in regard thereto. The subject was illustrated by lantern slides.

The thanks of the meeting were extended to the speaker.

Adjourned.

ALFRED RIGLING,
Acting Secretary.

Electrical Section.—A meeting of the Section was held in the Hall of the Institute on Thursday evening, February 24, 1921, at 8 o'clock, with Mr. W. C. L. Eglin in the Chair.

The paper of the evening, entitled "The Economic Aspects of Railway Electrification," was read by Mr. A. H. Armstrong, M.E., Chairman, Electrification Committee of the General Electric Company, Schenectady, New York. After a review of the present condition of the railway service, due largely to the soaring price of fuel and labor, consideration was given to the economic advantages which will result from the universal replacement of the steam engine. An account was given of the development of the electric locomotive and its use on the several railway lines throughout the United States. Attention was also called to its great reliability and low cost of maintenance. The subject was illustrated by lantern slides.

After a discussion the thanks of the meeting were extended to the speaker. Adjourned.

R. B. OWENS,
Secretary.

MEMBERSHIP NOTES.

ELECTION TO MEMBERSHIP.

(Stated Meeting, Board of Managers, March 9, 1921.)

RESIDENT.

MR. J. VINCENT HUFFNAGLE, 88 Elgin Avenue, Westmont, New Jersey,

MR. OSCAR G. SCHROM, 6017 Nassau Street, Philadelphia, Pennsylvania.

MR. J. LESTER WOODBRIDGE, 19th Street and Allegheny Avenue, Philadelphia, Pennsylvania.

NON-RESIDENT.

MR. THOMAS W. HICKS, 4516 Fremont Avenue, South Minneapolis, Minnesota.

MR. M. SELGA, Manila Observatory, Manila, Philippine Islands.

MR. J. M. SPITZGLASS, 2240 Diversey Boulevard, Chicago, Illinois.

MR. SPENCER J. STEINMETZ, 31 Evans Road, Brookline, Massachusetts.

CHANGES OF ADDRESS.

MR. FREDERICK M. BENNETT, 2516 Harlan Street, Philadelphia, Pennsylvania.

MR. EDWIN FRANK, care of C. H. Wheeler Manufacturing Company, Lehigh and Sedgley Avenues, Philadelphia, Pennsylvania.

MR. JOHN W. HILL, Rooms 45-46 Bodmann Building, 621 Main Street, Cincinnati, Ohio.

MR. S. C. HOLLISTER, Wig, Hollister & Ferguson, Land Title Building, Philadelphia, Pennsylvania.

MR. JAMES D. LEE, JR., 5929 Greene Street, Germantown, Philadelphia, Pennsylvania.

MR. EDWARD E. MARBAKER, 11416 Ashbury Avenue, N. E., Cleveland, Ohio.

MR. ORIN C. STOUT, Chillicothe, Barr County, Ohio.

MR. F. R. WADLEIGH, Assistant to President, Tuttle Corporation, 15 Broad Street, New York City, New York.

NECROLOGY.

Daniel Baugh was born near Downingtown, Chester County, Pennsylvania, on October 22, 1836, and died at Palm Beach, Florida, on February 27, 1921. He was educated at a private academy near his home and at the Fremont Seminary in Norristown.

In 1853 he joined his father and brother in the founding of a plant for the manufacture of fertilizers by artificial and chemical means. After two years of experimental and technical investigations the first super-phosphate was placed on the market. The plant has been in continuous operation since that time.

Mr. Baugh was greatly interested in art and the sciences, and for more than twenty-five years was President of the School of Design for Women. He contributed much of his time and wealth to the cause of education, especially in the field of medicine. Mr. Baugh was a member of many clubs and other organizations and his membership in The Franklin Institute dated from May 8, 1874.

Mr. George M. Newhall, Commercial Trust Building, Philadelphia, Pennsylvania.

Mr. H. B. Rosengarten, P. O. Box 1625, Philadelphia, Pa.

LIBRARY NOTES.

PURCHASES.

DALBY, W. E.—Steam Power. 1920.

DENNIS, L. M.—Gas Analysis. 1920.

FALK, G. K.—Chemical Reactions. Their Theory and Mechanism. 1920.

GRAUBAU, A. W.—Geology of the Non-Metallic Deposits. 1920.

HARROW, B.—Eminent Chemists of Our Time. 1920.

HEINEMAN, P. G.—Milk. 1919.

JOHNSON, C. M.—Rapid Methods for the Chemical Analysis of Special Steels. 1920.

LOVETT, W. J.—Applied Naval Architecture. 1920.

LOW, D. A.—Heat Engines. 1920.

MCKAY, G. L., AND C. LARSEN.—Principles and Practice of Butter Making. No date.

MATTHEWS, J. M.—Application of Dyestuffs to Textiles, Paper, Leather, and Other Materials. 1920.

POYNTING, J. H.—Collected Scientific Papers. 1920.

STOCKING, W. A.—Manual of Milk Products. 1919.

UNWIN, W. C.—A Treatise on Hydraulics. 1912.

VANSLYKE, L. L.—Modern Methods of Testing Milk and Milk Products. 1920.

WHITBY, G. S.—Plantation Rubber and the Testing of Rubber. 1920.

GIFTS.

Acheson Graphite Company, Electric Furnaces, Brass Melting, Acheson Electrodes in Use. Niagara Falls, New York, 1920. (From the Company.)

Air Reduction Sales Company, Cutting Cast Iron with Oxacetylene Torch. New York City, New York, 1920. (From the Company.)

Aluminum Company of America, Aluminum Electrical Conductors. Pittsburgh, Pennsylvania, 1920. (From the Company.)

American Institute of Mining and Metallurgical Engineers, Transactions, Vol. lxiii. New York City, New York, 1920. (From the Institute.)

Atmosphere Conditioning Corporation, Bulletin No. 50. Philadelphia, Pennsylvania, 1920. (From the Corporation.)

Bastian Blessing Company, Rego Welding and Cutting Apparatus. Chicago, Illinois, 1920. (From the Company.)

Batterman Truitt Company, Modern Ventilating Apparatus. Philadelphia, Pennsylvania, 1920. (From the Company.)

Boston Gear Works, Standardized Boston Gears. Chicago, Illinois, 1920. (From the Works.)

Brown, A. and F., Company, Power Transmission Machinery. New York City, New York, 1920. (From the Company.)

Bureau of Engineering, Annual Report for the Fiscal Year 1920. Washington, District of Columbia, 1920. (From the Bureau.)

Burton, Griffiths and Company, Ltd., B. S. A. High Speed Steel Milling Cutters, Reamers, and B. S. High Speed Steel Twist Drill. London, 1920. (From the Company.)

Canada Department of Mines, The Production of Iron and Steel. Ottawa, Canada, 1920. (From the Director.)

Carey, The Philip, Company, Catalogue No. 1352. Cincinnati, Ohio, 1920. (From the Company.)

Carpenter, George B., and Company, Catalogue No. 110. Chicago, Illinois, 1920. (From the Company.)

Chicago Engineer Supply Company, Cesco Boiler Tube Cleaners. Chicago, Illinois, 1920. (From the Company.)

Colgate University, Annual Catalogue, 1920–1921. New York City, New York, 1920. (From the University.)

Combination Pump Valve Company, Pump Valves for every Use. Philadelphia, Pennsylvania, 1920. (From the Company.)

Coppus Engineering and Equipment Company, Coppus Centrifugal Turbo Boiler Feed Pump. Worcester, Massachusetts, 1920. (From the Company.)

Cornell University, The President's Report, 1919–1920. Ithaca, New York, 1920. (From the University.)

Crescent Manufacturing Company, Catalogue No. 25. New York City, New York, 1920. (From the Company.)

Cutler Hammer Manufacturing Company, Steel Mill Control and for the Mine. New York City, New York, 1920. (From the Company.)

De La Vergne Machine Company, Municipal Power Plants. New York City, New York, 1920. (From the Company.)

Electric Controller and Manufacturing Company, Bulletin No. 1044. Cleveland, Ohio, 1920. (From the Company.)

Garratt-Callahan Company, Magic Boiler Preservative. Chicago, Illinois, 1920. (From the Company.)

Gas Combustion Company, The Bradshaw Burner. Pittsburgh, Pennsylvania, 1920. (From the Company.)

General Electric Company, Ltd., Switchgear High and Low Tension. London, England, 1920. (From the Company.)

General Radio Company, Bulletins of Electrical and Radio Laboratory Apparatus. Cambridge, Massachusetts, 1920. (From the Company.)

Greenfield Tap and Die Corporation, Catalogues Nos. 40, 42 and 43. Greenfield, Massachusetts, 1920. (From the Corporation.)

Hammett, J. L. Company, Catalogue for Basket Making and Miscellaneous Manual Art Supplies. Cambridge, Massachusetts, 1920. (From the Company.)

Hoover, Owens, Rentschler Company, Poppet Four-Valve and Uniflow Engines. Hamilton, Ohio, 1920. (From the Company.)

Institution of Naval Architects, Transactions for 1920, Vol. lxii. London, England, 1920. (From the Institution.)

Lietz, A., Company, Solar Ephemeris, 1921. San Francisco, California, 1921. (From the Company.)

Link-Belt Company, Book No. 435 and Book No. 352. Chicago, Illinois, 1920. (From the Company.)

Little, Arthur D., Incorporated, The Petroleum Outlook. Cambridge, Massachusetts, 1920. (From the Corporation.)

Liverpool Engineering Society, Transactions, Vol. xl, Forty-fifth Session. Liverpool, England, 1920. (From the Society.)

McAlear Manufacturing Company, Bulletin A, B, C, D, E, and Catalogue No. 25. Chicago, Illinois, 1920. (From the Company.)

Metal and Thermit Corporation, Thermit Insert Rail Weld. New York City, New York, 1920. (From the Corporation.)

Mine and Smelter Supply Company, Bulletin No. 60. New York City, New York, 1920. (From the Company.)

Mississippi State Geological Survey, Bulletin No. 60. Jackson, Mississippi, 1920. (From the Director.)

Mississippi Wire Glass Company, Booklet. New York City, New York, 1920. (From the Company.)

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BOOK NOTICES.

"DIE RELATIVITÄTS THEORIE EINSTEIN'S, von Max Born, Berlin; Julius Springer, 1920. 7 + 242 pages, with 128 figures and a portrait of A. Einstein.

The author of this book, issued as Volume iii of the series "Naturwissenschaftliche Monographien und Lehrbücher," is an accomplished theoretical physicist well known to specialists through his original investigations on the relativistically rigid body and of the physical properties of crystalline structures (space-lattices). Unlike most of his writings, thoroughly mathematical and accessible to a few people, the present work gives an easily readable, almost popular presentation not only of Einstein's special and general theories, but—what is more instructive for the beginner—a very sound and attractively written exposition of the physical bases of these theories. In fact, this preparation of the ground occupies as much as two-thirds of the volume. It guides the reader through the rudiments of space and time measurement (Chapter I) and a most happy presentation of the fundamental concepts and laws of classical mechanics (II) to "Newton's World System" (III) and the corresponding relativity principle with the Galilean transformation as its analytical expression. Inertia and centrifugal force find here an able treatment. Chapters IV and V are devoted to the fundamental laws of Optics and of Electrodynamics, respectively, and lead the reader in a masterly way from the rudiments of light theory to the dragging of light by matter and astronomical aberration, and from electro- and magneto-statics to Maxwell's electromagnetism and Lorentz's electron theory.

In due time and connection the Michelson experiment is described, and a good account is given of the contraction hypothesis which had to explain its nil-effect. This carries us at once to Einstein's Special Relativity Principle (VI), a beautiful chapter on the concept of simultaneity, on Einstein's elementary kinematics and the Lorentz transformation, illustrated by Minkowski's graphical representation of the behavior of moving clocks and measuring rods and deepened by a special section on appearance and reality. The addition theorem of velocities and special relativistic mechanics and optics of moving bodies follow, in a readable form, and the chapter closes with a good description of Minkowski's "absolute world" or space-time. Chapter VII, and last, perhaps a little too short, gives, however, an introduction into the General Relativity and gravitation theory which will be very helpful to a large circle of readers. It deals with the principle of equivalence and the insufficiency of euclidean geometry for general purposes, explains the use of Gaussian coördinates (labels) on the intuitive sub-case of a two-dimensional manifold, and, after a critical section on Mathematics and Reality, guides us into the metrics of the four-dimensional, space-time continuum, and the fundamental laws of the new mechanics. A description of the three well-known verifiable predictions of Einstein's new theory, two of which were crowned with success, and a general survey of Einstein's recent cosmological speculations on the one, and atomism on the other, hand (Macrocosmos and Microcosmos), close the chapter.

As an appendix Einstein's biography and a condensed chronological table are given, the latter starting from 300 B. C. (Euclid) and ending with 1879, the year of Einstein's birth.

LUDWIK SILBERSTEIN.

KOLLOIDCHEMIE. Ein Lehrbuch von Richard Zsigmondy. Dritte, vermehrte, und zum Teil umgearbeitete Auflage. Mit einem Beitrag: Bestimmung der inneren Struktur und der Grösse von Kolloidteilchen mittels Röntgenstrahlen; von P. Sherrer. 409 pages, contents, index, seven plates and fifty-eight illustrations in the text, 8vo. Leipzig, Otto Spamer, 1920. In paper, $4.20; bound, $5.00.

Ordinarily the third edition of a standard work would require but formal notice. Some allusion to the fact of the new edition is evidence that the work has met some "long-felt want," that banal expression of authors and reviewers, with notes of such improvements and additions as the authors had kindly set forth for the accommodation of reviewers, who often confine themselves to reading the preface, generally suffices for the report on the book. The present volume deserves more extended treatment. Everything that comes out of Germany is interesting to the thinking people of the other countries. The tragic history of the last six years is in every one's mind, and exclusive of those who were joined with the Teuton, scarcely any great nation is openly friendly. The author of the book feels keenly the situation, and in a postscript to the preface to this edition expresses himself as follows:

"May this edition serve as a slight evidence to co-workers in other lands that the search for truth is still being pursued in Germany with zeal, and that, in spite of sufferings and humiliations that have been accompanied with frightful incidents, we have not ceased to view phenomena objectively, and have endeavored

to acknowledge the merits of others. When the search for truth is the object, all accessory conditions must be left to one side. May those who think that this spirit is unworthy of confidence, consider that their own doings and conclusions will be subject to the calmer judgment of posterity. We will stand firmly in the confidence that the spirit of right, of justice and of love of truth will finally win out, and that the spirit of conciliation will eliminate the errors that have been left as a result of a period of great storm."

The general text of the book remains much the same as in former editions. All those who are interested in colloid phenomena are familiar with the author's exhaustive and vivid treatment of the subject. Additions have been made throughout, but in a footnote to the above-quoted postscript to the preface, Doctor Zsigmondy states that though he has zealously sought to secure the data presented in sources outside of Germany, yet since 1914 this has been difficult, and he expresses the desire that he shall be furnished with copies of contributions by co-workers in all parts of the world. It is to be hoped that this request will be heeded.

The most interesting of the new matter in the book is the appendix by Professor Scherrer on the structure and dimensions of colloid particles as determined by the X-ray. The remarkable results obtained by Laue's method applied to crystallized forms, carried out in considerable detail by the Braggs, naturally suggested extension to the formless masses, and it is along this line that Scherrer has worked with great energy and ingenuity. The essay is too long to abstract here, and is necessarily abstruse, but among the results attained is that the number of really amorphous substances is much smaller than heretofore supposed, inasmuch as many presumably amorphous powders have been found to be made up of finely dispersed crystalline masses. Amorphous boron is an instance. The molecular aggregations of liquids are not crystalline masses, and the result of studies show that certain phenomena are common to all liquids; and that, further, certain solids, such as glass and gelatin, exhibit strong analogies to liquids and may be regarded as sub-cooled masses.

The mechanical execution of the book is excellent, the paper being good and the type clear and neat. These are matters of moment nowadays, when so much inferior printing and paper is offered at high price.

HENRY LEFFMANN.

THE MICROSCOPE. ITS DESIGN, CONSTRUCTION AND APPLICATIONS. A SYMPOSIUM AND GENERAL DISCUSSION BY MANY AUTHORITIES. Edited by F. S. Spiers, B.Sc., F. Inst. P. 260 pages and contents, with many plates and illustrations in text, 8vo. London, Charles Griffin & Co.; Philadelphia, J. B. Lippincott Company. $5.00 net.

The numerous papers in this book covering many phases of the science of microscopy, both in theory and applications, are the results of discussions held at three different times. The initial symposium was on January 14, 1920, at the rooms of the Royal Society in London. An adjourned meeting was held on February 24th at Sheffield, and a further meeting in London on April 21st.

Experts in the various phases of the construction and application of the microscope contribute to the symposium, and it is unnecessary to say that the book contains a vast amount of interesting matter. The main participants were

the Faraday Society, the Royal Microscopical Society and the Photomicrographic Society, these groups being in coöperation with the Technical Committee of the British Science Guild. After some reference to the state of the art, and reminders of the importance to both Britain and America of so cultivating the practical side that these nations may be independent of all others, the general history of the microscope is taken up. It is shown by a quotation that Seneca knew that curved surfaces will magnify, and it is stated to be probable that the manuscript illuminators of the fifteenth century were familiar with moderate magnifying apparatus. The first illustrated publication which gives definite evidence of the use of a magnifying glass appeared in 1592 at Frankfort, bearing the name of George Hoefnagel. It consisted of a series of plates engraved on copper illustrating common natural objects, but drawn with great skill and minute accuracy. Some of the drawings reveal details that are hardly distinguishable to the unassisted eye. A Dutchman, Zacharias, miscalled Jansen, and his son, made microscopes before the year 1619. In 1665, Hooke published his famous book "Micrographia," in which he described using small drops or globules of glass. A fac-simile of the title page of the book is given.

A good deal of space is given to the subject of metallography, which though comparatively recent in its extensive applications, and in the efforts to construct apparatus for its pursuit, yet is really over a century old, the method having been first used by Widmanstätten in 1808, who polished a specimen of meteoric iron and examined the surface. His work is preserved in the title "Widmanstätten Figures" applied to the phenomenon. The practical application of the microscope to the study of metallic masses is due to Sorby, who began his work in this line in 1864. Years before, however, he had laid the foundation of one of the most important applications of microscopy—petrography—the extensive ramifications of which are now one of the most prominent features of mineralogy and geology.

The book is illustrated by a large number of excellent plates and many illustrations in the text. Necessarily, being made up of the contributions of many persons and of notes of extemporaneous discussions, the subject matter is somewhat disconnected, but the material presented is all of importance and value, and the book constitutes one of the best of recent publications in the field of pure and applied microscopy.

HENRY LEFFMANN.

A TEXT-BOOK OF PRACTICAL CHEMISTRY. By G. F. Hood, M.A. (Oxon.), B.Sc. (Lond.), and J. A. Carpenter, M.A. (Oxon.). xii + 514 pages and index, 162 illustrations, 8vo. Philadelphia, P. Blakiston's Son and Co. Price $5.00 net.

To those whose first descriptions of laboratory manipulations were derived from Morfit's Chemical Manipulations, the contrast with the modern works in this field is sufficiently striking. The introduction of electricity and the employment of vacuum apparatus have notably modified every-day procedures.

The present work is a very comprehensive description of methods in the preparation and testing of chemical compounds, covering both inorganic and organic fields. It is compactly and conveniently printed, and contains a very large amount of information, so that a student who should go through it

carefully and conscientiously will acquire a very satisfactory knowledge of the practical procedures in chemistry, and as these procedures are explained in their theoretical relations, such student will have also a good idea of the fundamental principles of the science. Eighty-eight pages are given to physical chemistry, in which important methods are elucidated, among which may be mentioned optical activity, electro-chemistry, spectroscopy and the phase-rule.

HENRY LEFFMANN.

A TEXT-BOOK ON SURVEYING AND LEVELLING. By H. Threlfall, M.Sc. Tech., Engineering Lecturer in the College of Technology, Manchester. 663 pages, illustrations, 12mo. London, Charles Griffin and Company, and Philadelphia, J. B. Lippincott Company, 1920.

The practice of surveying in this country is so different from that taught in England, that it is difficult to review an English work on this subject, and do justice to its author.

In this country, for instance, the chain is rarely used, except by the old-time county surveyor, the modern surveyor making his measurements either with steel tape and band, or in a rough country by the stadia method; the results obtained with the latter being as accurate as chaining, and at an economy of time and labor.

The use of the measuring rod for extreme accuracy, which apparently is stressed by Prof. Threlfall, has been practically abandoned in this country. Greater speed and as high a degree of accuracy is obtained by the use of steel bands, observing connections that reduce the percentage of error to such a minimum that the methods are employed in the measurement of U. S. primary base lines.

The description of the use of the Plane Table would be of little service to an American engineer, as his method and purpose in using this instrument are so radically different from those described by the author.

On the other hand, the chapters treating of "Cuttings and Embankments," and the adjustments for linear errors in a closed polygon survey, without affecting the angular measurements, contain some valuable information.

There is also a very excellent chapter on "Photographic Surveying" and the chapter on "Tacheometry," or as it is commonly called in this country, "Stadia Surveying," is complete and practical.

BENJAMIN FRANKLIN.

LABORATORY MANUAL FOR THE DETECTION OF POISONS. By Wilhelm Autenrieth, University of Freiburg i.B. Authorized translation by William H. Warren, Ph.D. Fifth American edition, 322 pages, contents, index and 25 illustrations, 8vo. Philadelphia, P. Blakiston's Son and Co. Price $3.50.

This work has been so long before the chemical profession that it needs little more than a notice of the appearance of a new edition. It is a translation from the fourth German edition, the same as was used in the preparation of the fourth American edition, inasmuch as a revision of the German work has apparently not yet appeared. There is also a special British edition, in which some subjects not found in the German original were included and are also treated in the American edition. Among these is the vexing question of

"normal arsenic." For many years chemists were satisfied that arsenic is not a normal constituent of the human body. As the delicacy of tests increased, however, it became possible to detect extremely minute amounts of the elements, and Gautier, in 1841, asserted that he was able to find traces of arsenic in certain organs of the human body without there being any reason to assume its direct introduction. The subject was extensively examined, but the results given by Kunkel, as quoted in the book before us, are that whatever traces of arsenic occur in human organs they are too small to have any value in toxicologic examinations. It must also be borne in mind that in most cases of arsenic poisoning there is a symptomatology which aids in the diagnosis. It is to be noted that all the claims for the existence of arsenic normally in the body are from French investigators, and are all more than a dozen years old.

The American editor has wisely added a considerable amount of matter on methyl alcohol, now so prominent as a poison. Unfortunately, neither this name nor "wood spirit" appears in the index. Important literature on the subject has been cited, but Gettler's exhaustive investigation, published in *Journal Biol. Chem.*, seems not to have been used.

It is a puzzling question as to how far a translator should incorporate information local to the country for which the translation is intended. The practices of different nations are often very different and users of the book may be misled if the translation is made too close. In the present case, for instance, it is stated that strychnine nitrate is the salt commonly used in medicine, but the American practice gives preference to the sulphate. It is to be regretted that Reinsch's test for arsenic is not included in the list, for it is specially applicable as a preliminary test on stomach contents, vomited matters and other complex organic mistakes. It is, further, a delicate test, and when carefully carried out, reliable.

It seems a pity that the publisher has been put to the expense of printing the structural formulas of many of the alkaloids. These have no value in practical toxicology, which is essentially empiric in its methods.

HENRY LEFFMANN.

AN INTRODUCTION TO CHEMICAL PHARMACOLOGY. PHARMACODYNAMICS IN RELATION TO CHEMISTRY. By Hugh McGuigan, Ph.D., M.D., University of Illinois. vii + 407 pages and index, small 8vo. Philadelphia, P. Blakiston's Son and Co. Price $4.00 net.

This work is an effort to bring together the data that bear on the relation between chemical composition and physiologic action. The author's view, as set forth in the preface, is perhaps more optimistic than the facts support, or as the book summarizes them. It is natural that the chemist should hold to the view that the composition of a substance should be the sole cause of its physiologic action, but such an opinion seems at present to be more a matter of faith than of demonstration. Dr. McGuigan holds that it is upon this phase of opinion, namely, reference of all physiologic action to composition, that science is entering. He asserts that the purely physiologic methods, in which changes of blood-pressure, respiration and heart rate are recorded, seem spent, and many are convinced that chemistry now offers the most hopeful method for the solution of many of the problems on pharmacology.

Changes, we are further told, in the functions of the body are due to the chemical reactions between the drugs and the tissues. "Physical changes also result, and it is often difficult to separate the purely physical from the purely chemical." It might be difficult to define exactly what is a physical and what a chemical change. Some distinguished chemists are of the opinion that this is a distinction without a difference.

Turning to the text of the work, it is found to give large space to the chemistry of drugs and to the tests and reactions relating to them. In fact, the proportion of space given to general chemistry is much larger than that devoted to the explanation of the relations between the chemical composition and the physiologic effect. There is a very large amount of information on the structure of the several classes of organic compounds. From an artistic point of view, the reviewer considers that most of the formulas take up too much room.

The author makes a distinction between "catalysts" and "enzyms," stating that the latter are all destroyed at 100°, and many of them at 60°. It seems to be intended that on the difference between enzyms and catalysts is based this difference of action of heat, but as the word "catalyst" is not in the index, and no further statement is given in connection with the section on enzyms, it is not certain upon what Dr. McGuigan bases it. It seems to be an unnecessary distinction, if the author reserves the term "catalyst" for inorganic bodies.

HENRY LEFFMANN.

ELEMENTARY ELECTRICAL ENGINEERING. By Ralph Preston Clarkson, Professor of Engineering, Acadia University, N. S. xvi + 187 pages, illustrations, 8vo. New York, D. Van Nostrand Company, 1920. Price, $2.00.

This book is intended for the use of students in Mechanical, Civil and Chemical engineering, also for those who need to acquire a considerable acquaintance with Electrical engineering calculations and machinery in a comparatively short time. The author has developed his purpose with considerable success, and has produced an excellent little text-book if properly supplemented by lectures. The book is so small for the extent attempted to be covered that its faults are greatly emphasized. Often the line is not sharply drawn between informal class talks and the conciseness demanded by a text-book. Too much merely elementary electrical physics is included in the earlier chapters; and many of the illustrations are of the catalogue type and employed irrelevantly. However, many principles of electrical engineering are explained in a style so lucid it is regrettable the author did not attempt a larger text written similar to that of the admirable chapter on the solution of circuits.

WILBUR M. STINE.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

Report No. 107, A High-speed Engine Pressure Indicator of the Balanced Diaphragm Type, by H. C. Dickinson and F. B. Newell, Bureau of Standards. 15 pages, illustrations, diagrams. Washington, Government Printing Office, 1921. This report describes a pressure-measuring device especially adapted for use in mapping indicator diagrams of high-speed internal-combustion engines. The

cards are obtained by a point-to-point method giving the average of a large number of engine cycles. The principle involved is the balancing of the engine cylinder pressure against a measured pressure on the opposite side of a metal diaphragm of negligible stiffness. In its application as an engine indicator the phase of the engine cycle to which a pressure measurement corresponds is selected by a timing device. The report discusses briefly the errors which must be avoided in the development of an indicator for light high-speed engines, where vibration is serious, and outlines the principles underlying the design of this instrument in order to be free of such errors. A detailed description of the instrument and accessories follows, together with operating directions. Specimen indicator diagrams are appended. The indicator has been used successfully at speeds up to 2600 r. p. m., the highest speed engine available for trial. Its sensitivity is approximately that of a standard six-inch dial gauge of the Bourbon tube type.

Report No. 109, Experimental Research on Air Propellers, IV, by W. F. Durand and E. P. Lesley. 11 pages, illustrations, diagrams. Washington, Government Printing Office, 1921. This is a continuation of a report on the same subject published in the Fifth Annual Report. The research was conducted in the aerodynamical laboratory of Leland Stanford Junior University, and the report was prepared under the direction of Dr. W. F. Durand and Prof. E. P. Lesley. The results of investigations made upon numerous propeller models at the request of the Subcommittee on Aerodynamics are given, as well as valuable data to those interested in the design of air propellers. The discussion accompanying the report is necessarily somewhat brief, as it is to be a part of the general report which will include a review of all the propeller investigations that have been conducted at Leland Stanford Junior University.

PUBLICATIONS RECEIVED.

An Introduction to Chemical Pharmacology. Pharmacodynamics in Relation to Chemistry, by Hugh McGuigan, Ph.D., M.D. 418 pages, illustrations, 12mo. Philadelphia, P. Blakiston's Son and Company, 1921. Price, $4.00 net.

Laboratory Manual for the Detection of Poisons and Powerful Drugs, by Dr. William Autenrieth. Authorized translation by William H. Warren, Ph.D. Fifth American edition. 342 pages, illustrations, 8vo. Philadelphia, P. Blakiston's Son and Company, 1921. Price, $3.50 net.

A Text-book of Practical Chemistry, by G. F. Hood, M.A., B.Sc., and J. A. Carpenter, M.A. 527 pages, illustrations, 8vo. Philadelphia, P. Blakiston's Son and Company, 1921. Price, $5.00 net.

U. S. Bureau of Mines: Technical paper 251, Ventilation in Metal Mines. A Preliminary Report, by Daniel Harrington. 44 pages, 8vo. Technical paper 280, Accidents at Metallurgical Works in the United States During the Calendar Year 1919, by William W. Adams. 31 pages, 8vo. Washington, Government Printing Office, 1921.

Canada Department of Mines, Mines Branch: Annual Report on the Mineral Production of Canada During the Calendar Year 1919. 82 pages, 8vo. Pre-

liminary Report on the Mineral Production of Canada During the Calendar Year 1920, prepared by John McLeish, B.A. Ottawa, King's Printer, 1920-1921.

National Advisory Committee for Aeronautics: Technical Notes No. 28. Loads and Calculations of Army Airplanes, by Engineer Stelmachowski. Translated from Technische Berichte, vol. iii, Section 6. 11 pages, 8vo. Technical Notes No. 32. Causes of Cracking of Ignition Cable, by F. B. Silsbee and J. B. Dempsey. 14 pages, plates, 8vo. Technical Notes No. 44. On the Resistance of Spheres and Ellipsoids in Wind Tunnels, by D. P. Riabouchinsky. Translated from Bulletin of the Aerodynamical Institute of Koutchino. 9 pages, diagrams, 8vo. Technical Notes No. 54. The Factors that Determine the Minimum Speed of an Airplane, by F. H. Norton. 9 pages, diagrams, 8vo. Washington, Committee, 1921.

Solutions of Acetylene in Acetone at High Pressures.—RAYMOND R. BUTLER (*Journ. Soc. Chem. Ind., Transactions,* 1921, xl, 25–26) has made a study of such solutions. Under the British regulations, acetylene may be dissolved in acetone in cylinders until a pressure of 15 atmospheres is reached. For each increase in pressure of 1 atmosphere, the solution expands approximately 4.4 per cent. in volume. If a cylinder contains 40 per cent. of its volume of acetone, the solution of acetylene will occupy 65.6 per cent. of the volume of the cylinder when the pressure is 15 atmospheres. The cylinder is ordinarily filled with porous material, which has a porosity of 80 per cent., and therefore contains 20 per cent. of its volume of solid matter. Therefore, the total free space actually present in the charged cylinder is but 14.4 per cent. of its total volume. No evidence was found of the formation of any compound between the acetone and the acetylene.

J. S. H.

New Test for Cobalt.—According to S. A. BRALEY and F. B. HOBART, of the University of Illinois (*Journ. Am. Chem. Soc.,* 1921, xliii, 482–484), dimethylglyoxime always reacts with aqueous solutions of cobalt salts, in the presence of either sodium acetate or ammonia, to produce a brown color. This brown color does not disappear upon the addition of mineral acids, while the color of other metallic glyoximes is discharged by such acids. Therefore, the reaction may be used as a sensitive qualititative test for cobalt in the absence of such interfering substances as copper and iron. If elements, other than nickel, which give colored solutions or precipitates with sodium acetate and dimethylglyoxime, be absent, the brown color of cobalt dimethylglyoxime may be used for the colorimetric determinatoin of cobalt. If both cobalt and nickel be present, the nickel is determined by precipitation with dimethylglyoxime; and the cobalt is determined colorimetrically in the filtrate from this precipitate.

J. S. H.

CURRENT TOPICS.

Some Experiments in Connection with the Injection and Combustion of Fuel-oil in Diesel Engines. Engr. Commander C. J. HAWKES, R. N. (*Northeast Coast Institution of Engineers and Shipbuilders,* November 26, 1920.)—This paper deals with experiments at the Admiralty Engineering Laboratory on the injection and combustion of fuel-oil in the Diesel engine.

With the air-injection system, a definite quantity of fuel-oil is pumped into the fuel-saving casing, and when the valve lifts, compressed air provided by a high-pressure air-compressor blows the oil into the cylinder in a finely divided state.

In the solid-injection system, no air-compressor is required. The fuel pump raises the oil throughout to a comparatively high pressure, and when the fuel valve lifts, the requisite quantity is forced by its own pressure through a number of small holes in the sprayer, being thus split up into a mist.

The experiments with the solid-injection system will be mentioned first, and subsequently some on the air-injection system.

It will not be possible in this abstract to do more than to give an idea of the nature of the experiments and some of Mr. Hawkes's conclusions therefrom.

Experiments on the Solid-injection System.—For the experiments on the solid-injection system, use was made of a single-cylinder, four-stroke engine 14½" by 15", capable of developing 100 B. H. P. at 380 R. P. M.

An investigation was made to ascertain the cause of and the remedy for the sticking of the exhaust valve (the principal part of the remedy consisted in adding a deflector to protect the valve spindle from the rush of exhaust gases); another to determine the effects of the different numbers and sizes of holes in the sprayer. Most of the tests having been made under pressures, powers, and other conditions usual in such cases. It was found that under such conditions the best all-round results were obtained by the use of five 0.016-inch holes per sprayer.

Experiments were made to ascertain the effect of fitting steel plates to the top of the alloy piston, generally with the result of increasing the fuel consumption.

Others to find out whether this was due partly to some of the fuel-oil assuming the spheroidal state on striking the hot piston, thus delaying the vaporization and combustion.

At 4000 pounds per square inch pressure, however, the roller began to leave the cam, and better results were obtained by increasing the spring load up to 850 pounds, but no advantage was

gained by increasing it further. Tests were made on the conditions that brought about "jumping" of the valve.

A study was made on the effect of the length of holes in the sprayer, and a comparison between the 0.016-inch and the 0.019-inch ones, at about 100, 90, 75, 50, and 25 B. H. P. He concludes that the proper number, size, and angle of holes in a sprayer depends upon the mean pressure, the viscosity, the mean indicated pressure, and the distance the jets have to penetrate into the combustion chamber; also on the speed of the engine. The determination of the number, size, and angle of the holes for a given engine, however, is largely a question of trial and error.

Many other experiments were made on the solid-injection system which will not be referred to here.

Air-injection System.—A large number of very important tests were also made on the air-injection system, dealing with many important details, and so comprehensive that not only a great deal of valuable information can be obtained from them in regard to details, but also Mr. Hawkes is enabled to compare the two systems as to their advantages, disadvantages and idiosyncrasies.

G. L.

Stenches for Blue Water-gas and Natural Gas. (*Tech. Paper 267, U. S. Bureau of Mines,* by S. V. KATZ and V. C. ALLISON.)—Loss of life and property frequently result from leakage of fuel and illuminating gases, especially the former. The non-enriched water-gas used for fuel purposes alone, and commonly called "blue water-gas" on account of the flame it produces, is especially dangerous, as it contains about one-third its volume of carbon monoxide, and is almost inodorous. Certain German cities require such gas to be always supplied with a stench to give warning of its escape in an unconsumed form. Natural gas has also little odor. Obviously, the stench chosen should be characteristic, essentially disagreeable, and capable of retaining itself in admixture with the gas through all the transportation that this undergoes. Two dozen substances that seem to be applicable to this purpose have been investigated by the authors of the bulletin. Some of these are too expensive for large scale use, others too liable to cause corrosion of pipes, others again not sufficiently disagreeable to serve as a warning. It must also be borne in mind that a very large number of persons have defective sense of smell, and marked odors may be present in their environment and not be detected by them.

Details are given in the bulletin of the methods determining the value of the several stenches and of the results of these determinations. Some stenches containing notable amounts of sulphur may be objectionable on account of the sulphur oxides that will be added to the air by the combustion of the gas containing them. Wide differences were observed in the efficiency of the

substances examined. Amyl thioether ($C_5H_{11}S$) gave the highest odor with the smallest concentration, only 0.4 mg. per cubic foot being sufficient to give strong intensity. Judging by market price alone, the two cheapest stenches which impart a strong odor are amyl acetate and nitrobenzene, but both of these are unsatisfactory because the odors are not unpleasant to many persons. Ethyl hydrosulphide (ethyl mercaptan, C_2H_5HS) and pyridin seem to be the only other stenches with highly disagreeable odors that are quoted at prices that seem worthy to be considered for large-scale use. Pyridin is especially suitable, for although the pure article is quoted at $2.50 per gallon, an impure article, which serves as well, can be obtained from the acid washings of light oils. Phenyl isocyanide has an extremely disagreeable odor, and, though not listed as a commercial chemical, can be prepared by comparatively simple and inexpensive methods. Conservative figuring shows that gas can be probably satisfactorily impregnated with it at a cost of less than one cent per thousand cubic feet.

In view of the strong trend to electric supply for lighting and power, with the consequent relegation of gas to heating purposes, and, therefore, the low enrichment of it, the use of some powerful stench seems to be a necessity for the protection of life and property.

H. L.

The Ultra-micrometer; an Application of the Thermionic Valve to the Measurement of Very Small Distances. R. WIDDINGTON. (*Phil. Mag.*, November, 1920.)—In a circuit containing inductance and capacity the frequency of the electrical oscillation natural to such a combination is dependent on the product of the inductance and capacity. If either of these varies, then the frequency varies also. Suppose the capacity is in the form of a condenser consisting of two parallel plates. A change in the distance between these causes a change in capacity and this in turn brings about a change in the frequency of oscillation. The author calculates that, one-thousandth of an inch being the distance separating the plates, a change of one vibration per second will be brought about by altering this distance by two billionths of an inch—and such a change in frequency can actually be detected.

To realize as far as may be the possibilities indicated by theory the following arrangement was devised: An oscillating valve circuit was set up, including the parallel plate condenser in which change in the interval between the plates was to be investigated and also a loud-speaking telephone joined to a three-stage transformer amplifier. This apparatus gave a frequency of about one million per second. To make evident any change in this frequency a second valve circuit was placed near the first. Its frequency could be adjusted by means of a condenser so as to nearly equal that of the first. Thus the telephone was caused to

emit a loud, audible note, whose pitch could be studied against the background of another note maintained at a standard pitch. The pitch of the telephone note was tuned to this pitch. Let the distance between the plates in the first circuit change. A change in the pitch of the note coming from the telephone follows, and in consequence there is a difference in the number of beats heard in a second. A careful study showed that in practice altering the interval between the plates by one two-hundred-millionth part of an inch caused a perceptible change in the number of beats per second. The two notes were brought back into unison by moving the pointer in a variable condenser in the second circuit. When the distance between the plates in the first circuit was made to change by a relatively large distance, such as one one-hundred-thousandth of an inch, it was found that shifting the condenser pointer one-tenth of a degree compensated for separating the plates about three ten-millionths of an inch.

The method is so sensitive that the placing of a British penny on a stout bench supporting the apparatus caused a perceptible audible change, because it bent the bench, tilted the supports and changed the distance from one condenser plate to the other. In view of the fact that the wave-length of the shortest waves of visible light is about one sixty-thousandth of an inch it is seen that this new method of linear measurement can determine distances very much smaller than the wave-length of light; indeed, it is applicable to lengths as small as the diameter of an atom.

G. F. S.

New Foods at a Banquet.—The farewell banquet on February 16th tendered to Secretary Meredith by the scientific workers of the Department of Agriculture, was marked by inclusion in the menu of several articles of food that have been made available by the labors of the department. Two of these articles were materials, for the preparation of which patents have been issued to their devisors, but laid open to public use. These are the "perfect bread," the result of studies by Dr. Carl O. Johns and A. J. Fink, being the first food product furnishing a completely balanced ration, and candies made from sweet-potato sirup. The formula for the latter item has been patented by Doctor Gore. Other items of the menu were American roquefort cheese, saratoga chips made from the newly introduced vegetable, dasheen, a new soy-bean sauce developed by Doctor Church and new varieties of grapes, imported under the direction of Doctor Husmann.

H. L.

Cellulose Acetate and Artificial Silk. (*The Chemical Age.*)—Cellulose acetate, from which dope for aeroplanes and airships is made, has proved itself to be of the utmost value in the aircraft industry, and the conception of laying down and completing the

works in the stress of war, and the establishment of a new key industry of vital importance in war, with huge potentialities in peace time, was a marvelous achievement; it was due to the genius of Doctors Henry and Camille Dreyfus. Before the war the value of cellulose acetate was appreciated by few in this country, and there was nobody capable of dealing with the enormous demand which the Air Force program created.

The general belief has been that while acetate of cellulose was a perfect raw material for the manufacture of artificial silk, it suffered the serious drawback of being difficult or impossible to dye.

Contrary to this opinion, the British Cellulose Company has proved that, after most exhaustive trials extending over a considerable period, during which the most minute studies and tests both in the technical laboratories and in bulk have been made, the silk can be dyed in a very easy manner. The operation can be carried out by any dyer in this country without special skill or pre-treatment and by direct dyeing with practically all dyes. The basic, the azo, the acid, alizarine, and other dyes can be used successfully, and in each case the resultant dyed silk is fast to light and is washproof.

The dyed silk has been submitted to tests of ten hours under the Quartz lamp—tests which would practically destroy basic dyes on real or artificial silk, and the results have shown that the silk is not affected in any manner. One outstanding characteristic observed in dyeing the silk is that all dyes are directly absorbed without any pre-treatment whatever. Dyes which are insoluble in water, immediately dye British cellulose silk on immersion in the bath.

The action of the dyes in the case of cellulose acetate silk is believed to be a rare chemical affinity and not a physical absorption. Another interesting feature is that the basic dyes which are not fast to light nor washproof, become so when applied to cellulose acetate silk.

Cellulose acetate silk, both dyed and undyed, has a lustre which is excellent, and it possesses a scroop equivalent to that of natural silk. Many and continuous tests in weaving cellulose acetate silk, both dyed and undyed, have been carried out by large manufacturers of silk goods, piece goods, and ribbons, and the reports are of the most satisfactory character. Indeed, these manufacturers have expressed their astonishment at the easy manner in which the product has worked in their textile machinery. Whether they were using it for warp and weft at the same time, or for one of these, or whether they were working in conjunction with natural silk, the results have been excellent. The absence of breakages under trying conditions has commended it highly to the workers.

This feature is due to the great elasticity of cellulose acetate

silk. In this respect it even excels natural silk. This feature permits the silk to be woven on looms running at the highest speed.

Plant has also been installed for the manufacture of non-inflammable celluloid, termed "celastoid." This product has all the advantages of celluloid without the great disadvantage of high inflammability. Such a material is of great value to the celluloid trade, where the high price of camphor has seriously restricted the manufacture of celluloid. The day is not far distant when the use of dangerous highly inflammable celluloid will be prohibited.

The marvelous insulating property of cellulose acetate silk or sheeting is a factor that has aroused great interest in the electrical and allied trades, and the long-sought-for non-inflammable accumulator boxes, wind screens, and a multitude of other articles of necessity will shortly be placed on the market.

The Crystal Structure of Ice. D. M. DENNISON. (*Phys. Rev.*, January, 1921.)—Distilled water was frozen in a capillary tube. The tube with the ice was rotated during a ten-hour exposure to X-rays as a result of which a series of twelve lines were obtained. The method was that of A. W. Hull's crystal powder photographs. The interpretation of the results gives an axial ratio of 1.62, while the value furnished by the crystallographer is 1.617. The number of molecules of H_2O per cu. cm. is calculated to be 3.154×10^{22}. The volume of an elementary prism can likewise be derived from the experimental results and is found to equal 0.6478×10^{-22} cu. cm. From these two it follows that in an elementary prism there are 2.04 H_2O molecules. "Ice belongs, then, to one of the two alternate arrangements which inelastic uniform spheres may assume if packed as closely as possible. This is the same form that magnesium atoms take. . . . With increased knowledge of crystal structure these data may furnish information regarding the shape of the molecule of water. With the hexagonal close packed type of lattice each prism contains on the average one molecule. The result calculated above indicates that in ice crystals the molecules of water are of the form $(H_2O)_2$ or H_4O_2." G. F. S.

An Electromagnetic Theory of Gravitation. H. A. WILSON. (*Phys. Rev.*, January, 1921.)—When an electric system is placed in a medium whose specific inductive capacity varies from point to point it experiences a force tending to move it toward parts of the field where that quantity is greater. A like force acts in a field with variable magnetic permeability. The author bases a theory of gravitation on these facts with the assumption that both the specific inductive capacity and the permeability of the ether are modified by the presence of matter and, further, that the dimensions of the body acted on change when it passes

from one part of the variable field to another. He is able to show that his theory is consistent with the inverse square law, with the deflection of light by the sun and with the gravitational effect upon the frequency of light emitted by an atom. "It may be said that since matter is certainly partly electrical and since the refractive index of the ether certainly varies near large masses, it seems certain that part, at least, of the observed gravitational forces must be due to an action of the kind considered in this paper, so that it is satisfactory to find that it is possible to explain the whole attraction by means of this kind of action."

G. F. S.

The Charge on the Atomic Nucleus and the Law of Force. J. CHADWICK. (*Phil. Mag.*, December, 1920.)—"The theory of the nuclear constitution of the atom, put forward by Sir Ernest Rutherford in 1911, has been confirmed by evidence gathered from such various sources that it now forms the foundation on which the development of atomic physics is based. On this theory the positive charge associated with an atom is concentrated on a massive nucleus of small dimensions, surrounded by a distribution of electrons extending over a distance comparable with the diameter of the atom, as usually understood.

"The physical and chemical properties of an element are determined by the charge on the nucleus, for this fixes the number and arrangement of the external electrons, on which these properties mainly depend. The mass of the nucleus influences the arrangement of the electrons only to a very small degree. The nuclear charge is thus the fundamental constant of the atom and the question of its actual magnitude of great importance for the development of atomic theory."

As the consequences and implications of Rutherford's theory became understood attempts were made to connect the nuclear charge with other atomic constants. "van den Broek suggested that the nuclear charge might be equal to the atomic number of the element, *i.e.*, the number of the element when all the elements are arranged in order of increasing atomic weight." The palmary significance of the atomic number in this connection was brought forward by the brilliant young British physicist, Moseley, whose untimely death at Gallipoli was the greatest single loss to science inflicted by German aggression. He showed that the X-ray spectra of the elements was dependent on the square of a number which became greater by one when passage was made from one element to the element of next higher atomic weight. "On the nuclear theory of atomic structure this characteristic number must be closely connected with the charge on the nucleus, and Moseley concluded that the number gave in fundamental units the actual value of this charge. This is one of the most important generalizations in modern physics, and gives a starting-point for

the development of the external structure of the atom." The only direct method of measuring the charge on the nucleus is by studying the single scattering of alpha particles. When a pencil of these falls on a thin sheet of matter, the number of the scattered particles falling per second on a unit area of screen at a known distance and angle with the pencil is connected with the number of particles per second in the pencil by a formula in which every quantity is either a known constant or a measurable quantity except the nuclear charge of the scattering atoms. This charge can therefore be calculated from the formula, when the results of experiment are inserted in it.

The direct as well as the scattered alpha particles were counted by the scintillations they produced upon the same zinc sulphide screen. If there were thirty scattered particles per minute, there would be about 20,000 direct particles in the same time. To count this large number a rotating disk with a slit was interposed in the path of the pencil before it reached the screen, so that only a known fraction of the particles could pass. Thus the number to be observed was made so small that it could readily be counted.

Experiments were made for three metals, platinum, silver and copper. In all cases the particles counted numbered some thousands. N means the number by which the fundamental charge of electricity, the charge of the electron, must be multiplied in order to get the nuclear charge of an atom of the metal.

Metal.	N.	Atomic Number of Metal.
Platinum	77.4	78
Silver	46.3	47
Copper	29.3	29

The atomic number of the metal is derived from its X-ray spectra, while N comes from the experiment. The agreement is striking and Moseley's conclusion is confirmed in a remarkable way. An examination of further experimental data leads to the conclusion that the inverse square law holds true in the region of investigation, *i.e.*, within one hundred-billionth of a centimeter from the nucleus.

G. F. S.

Lime Nitrogen.—The claim has been made that lime nitrogen or commercial calcium cyanamide produces injuries of the skin and of the respiratory tract, acts as a poison, and gives rise to a disease with characteristic symptoms—"lime nitrogen disease." SIEBNER (*Chemiker Zeitung*, 1920, xliv, 369–370, 382–383) has made an elaborate study of the subject, and draws the following conclusions: The injuries to the skin are due to free caustic lime which occurs in the cyanamide dust; the injuries to the respiratory tract are exactly the same as those produced by any dust. Cal-

cium cyanamide is not a poison; the amount required to kill a dog is 0.23 gram; a rabbit, 1.4 gram; and a man approximately 40 to 50 grams; the effect of small doses is not cumulative. Most other chemicals which are used as fertilizers, are more toxic, and have a cumulative effect. The lime nitrogen disease appears only if the individual imbibes alcoholic liquors while exposed to cyanamide dust or shortly thereafter. Therefore calcium cyanamide may be used with perfect safety as a fertilizer. The only precautions necessary are those usually taken in handling materials which may yield an alkaline dust. Certain beverages may not be drunk while the workman is exposed to the dust.

J. S. H.

Chemical Evidence of Fatigue.—ERNEST L. SCOTT and A. BAIRD HASTINGS (*Public Health Reports*, 1920, xxxv, 2445–2462) have made elaborate analyses of the urine of resting men, and of men engaged in work of varying degrees of severity. Among their findings is the fact that the absolute quantity of free or unconjugated phenols excreted in the urine was increased slightly by moderate work, and greatly by strenuous labor. Hence the amount of free phenols excreted in this manner may be a factor in severe fatigue.

J. S. H.

Aniline Vapors in Factory Air.—MIRIAM STEWART ISZARD, of the University of Pennsylvania (*Journal of Industrial Hygiene*, 1920, ii, 259–266) has found that aniline vapor is present in the atmosphere in more or less toxic concentration during the dropping of the reducer in the manufacture of aniline, and during the emptying of the phenylglycine dryers in the manufacture of indigo. However, the workmen are constantly moving about, and do not continuously breathe air with a high aniline content. Air at the floor level contains more aniline than does air at the respiration level.

J. S. H.

Trithiocarbonates and Perthiocarbonates.—According to ERNEST WICKMAN YEOMAN (*Jour. Chem. Soc.*, 1921, 119, 38–54), trithiocarbonates are salts of the acid H_2CS_3, and perthiocarbonates are salts of the acid H_2CS_4, thus sodium trithiocarbonate is Na_2CS_3, and sodium perthiocarbonate is Na_2CS_4. A trithiocarbonate may be obtained by the reaction of the hydrosulphide (sulphydrate) of a metal with carbon disulphide, a perthiocarbonate by the reaction of the disulphide or polysulphide of a metal with carbon disulphide. In the preparation of the sodium, potassium, and ammonium salts, absolute alcohol is used as the solvent; both alcohol and water have been used as solvents in the preparation of the alkaline earth salts (barium, calcium, strontium, and magnesium). Free trithiocarbonic acid apparently is soluble in water, while free perthiocarbonic acid is an insoluble

red oil. Aqueous solutions of trithiocarbonates are red, those of perthiocarbonates yellow in color. One molecule of trithiocarbonate is able to combine with one atom of sulphur to form one molecule of perthiocarbonate.

J. S. H.

Spontaneous Ignition of Fire Engine Hose While in Use.—This phenomenon is described by A. H. GILL, of the Massachusetts Institute of Technology (*Jour. Ind. and Eng. Chem.*, 1921, xiii, 168). The rubber hose was provided with two jackets of heavy cotton fabric; a new section, 50 feet in length and 2½ inches in diameter, was used in a test; cold river water was pumped through it at the rate of approximately 250 gallons per minute. The vibration produced in the hose by the pump, caused severe chafing of the cotton jackets, and thereby generated great heat; finally the hose took fire between the cotton jackets; and both jackets were burned through on an area 2 inches long by 1⅛ inches wide. The same result was obtained in several tests, using different types of fire engines and different makes of standard, high-grade hose. In some tests the cotton jackets became charred in approximately fifteen minutes.

J. S. H.

On the Closure of Small Cavities in Rocks Exposed to High Pressures. J. JOLY. (*Phil. Mag.*, December, 1920.)—The specimens of rock examined were in the form of spheres composed of two hemispheres with a common plane surface. In one of these a small hemispherical cavity was centrally ground, or a cavity was provided by laying a steel washer between the two hemispheres. The pressure was got by using a hydraulic press. The temperature was that of the room and some of the tests lasted for months. It was clearly shown " that in thirty tons on the plunger, that is, 38.70 tons or 88,717 pounds per square inch, we have a pressure which is certainly sufficient to close cavities in granite, basalt, obsidian, or limestone."

G. F. S.

Fat Content of Butter.—The technic of the Babcock test for the determination of the fat content of milk or cream has been modified by NELSON W. HEPBURN (*Cornell University Agricultural Experiment Station Memoir 37*, 663–690 (1920)) so that this test may be used for the determination of the fat content of butter.

J. S. H.

A Series of Flights Made with a Free Helicopter. E. OEHMICHEN. (*Comptes Rendus*, February 14, 1921.)—The helicopter had two propellers of diameter 6.4 metres, which revolved in opposite directions. A stabilizing balloon containing hydrogen was rigidly attached to the chassis of wood. This sustained about 20 per cent. of

the total weight of 336 kg., leaving 255 kg. to be lifted by the screws which were driven by a 25-horsepower motor of old type. In the month of January, 1921, Mr. Oehmichen made several flights on board this aircraft. He went up only to a height of 3 metres above the ground, having a certain distrust of parts of the apparatus, and carrying no parachute. He reports an absence of pitching in the vertical plane containing the axes of the two screws, while there was considerable rolling. There was a remarkable stability in altitude. Landings without rebound were made when there was no wind.

The author lays stress on the profile of the screws which he planned to resemble the outlines of the wings of moths observed in motion by a stroboscopic method.

The last series of flights were made in the presence of an officer formally designated to be a witness.

G. F. S.

The Problem of Soaring Flight. E. H. HANKIN, Chemical Examiner to Government, Agra, India. (*Proc. Cambridge Phil. Soc.*, Michaelmas Term, 1920.)—Two kinds of soaring flight are shown by birds, flying-fishes and dragon-flies. In slow flight speeds of from 11 to 22 miles per hour prevail, while in rapid flight the speeds range from 33 miles per hour in the case of dragon-flies to 45 miles per hour for vultures. In the slow soaring flight of birds and fishes the tips of the wings are at a higher level than the body, while they are either flat or below the body in rapid soaring flight. As a rule, sunshine must be present for slow soaring flight to be possible, while wind is indispensable for rapid soaring flight.

F. Handley Page remarks: "Doctor Hankin's discovery of the soaring flight of dragon-flies and flying-fishes affords a means of more closely investigating the phenomena of soaring. Observation of birds soaring at 2000 or 3000 feet is difficult compared with the observation of insect flight at a few yards' distance."

Cranes in a flock while in soaring flight keep their relative distances with great exactitude. "They resemble a number of dead birds pinned on a blue wall." This "furnishes a clear proof that the energy involved does not come from any chance or irregular currents of air." There remain two possible causes of such regular flight, *viz.*, unobserved wing motions or some condition that is uniform through wide stretches of the air. Both dragon-flies and fishes retard their flight by adjusting parts of their bodies so as to act as brakes. This seems to rule out undiscovered wing motions as the cause, for, were flight due to such motions, it would appear probable that the speed of flight would be regulated by change in the wing motion and not by a braking adjustment. Moreover, an albatross cannot soar in calm weather near sea level. This it should be able to do, were its soaring dependent on imperceptible wing motions.

Lateral gusts of wind are not the cause of soaring as is shown by the position of the wings which is such that in some cases the thrust

of the gust would force the flying organism downward and not upward. Ascending air currents are ruled out as a cause since inland soaring birds avoid them so long as the sun shines. There is some reason to hold that the turbulence of the air may be a factor in soaring flight, but the burden of the evidence is against it. A soaring dragon-fly may be seen gliding in the midst of a group of flapping flies. "What form of preëxisting air movement can be imagined that propels the soaring dragon-fly and yet has no effect on the flapping dragon-fly, though the latter is of lighter weight and loading?"

Having demolished all suggested explanations the author concludes "that soaring flight is inexplicable in the light of existing knowledge," and suggests that experimental investigations be undertaken, since observation alone has failed to furnish the solution of the enigma.

In India the boys play with a puttung, a kite made of paper and bamboo. In a proper wind this flies stably at the top of a vertical string. In this particular, as well as in others, it shows itself akin to the soaring of birds and suggests itself as a promising beginning for an experimental attack upon the problem.

G. F. S.

F. W. ASTON and G. P. THOMSON announce, in *Nature*, February 24, 1921, that their **experiments with positive rays** show lithium to be composed of two isotopes having the atomic weights 6 and 7, respectively. The former preponderates. The relative proportions of the two correspond to the atomic weight of lithium, 6.96.

G. F. S.

Efficiency in Industry. (*Nature*, February 24, 1921.)—The *Daily Mail* of London recently organized an exhibition for the purpose of emphasizing the advantages of applying scientific principles and results to industry. On the historical side the University of London presented the development of the thermionic valve from the lamps of 1887 made with internal plates by J. A. Fleming to study the Edison effect up to the most recent type of valve. There was also on exhibit apparatus used by Sir William Ramsay in his study of the rare gases as well as electrical apparatus employed by Clerk Maxwell.

A wireless set was shown, weighing 20 pounds only, yet capable of receiving messages from continental stations. Chance Brothers exhibited "Crookes" glass for protecting the eyes. This absorbs the ultra-violet part of the spectrum while allowing the visible spectrum to pass. Various devices were shown by which colors can be matched in artificial light.

The range of the exhibition was much wider than would be inferred from the exhibits just cited. The interest manifested is indicative of the growing appreciation in Great Britain of the importance of science to national welfare in peace as well as in war.

G. F. S.

Readers who are interested in the **Principle of Relativity** and who have perhaps already read the essay on this subject to which the *Scientific American* awarded its prize should not neglect to read the issue of *Nature* dated February 17, 1921. By far the larger part of the number is devoted to fourteen papers all dealing with relativity. Among the authors are EINSTEIN, the protagonist of the principle, SIR OLIVER LODGE, SIR FRANK DYSON, NORMAN CAMPBELL, J. H. JEANS and A. S. EDDINGTON. H. A. LORENTZ represents Holland in the symposium, while C. E. ST. JOHN, from the Mount Wilson Observatory, is the sole American contributor. It is interesting to note that DOROTHY WRINCH is one of the joint authors of the article on "The Relation Between Geometry and Einstein's Theory of Relativity." The history and the experimental verification of the new and revolutionary principle are discussed as well as its physical and metaphysical aspects. No French author contributes to this group of papers, and in the bibliography at the end of the collection there seem to be but three references to publications in the French language, and of these one was written by the great Dutch physicist, Lorentz. Have the physicists of France been so dedicated to the defence of their country that they have found no time for the elaboration of the principle, or is this an illustration of the failure of the maxim "Scientia non scit patriam"?

G. F. S.

Magnetic Susceptibility of Low Order. E. WILSON. (*Electrician*, March 11, 1921.)—Three lectures on this subject were given before the Institution of Electrical Engineers. Though the high values of the susceptibilities of ferromagnetic substances usually fixes attention upon this small group, it is none the less true that the much more numerous group of substances possessing small susceptibility, either positive or negative, is well worth considering as well from the practical as from the theoretical point of view. The practical aspect of these lectures is their discussion of the separation of minerals by recourse to their different susceptibilities. Thus the deposit producing monazite contains zircon, which is non-magnetic, and ilminite which has a higher susceptibility than the third constituent, monazite. A rather weak field will separate the ilminite from the other two, while the subsequent application of a stronger field will separate the monazite from the zircon. In order to design magnetic separators the magnetic properties of the constituent minerals must be measured. Hence the first lecture discusses methods of determining the susceptibility, the magnetometer, P. Curie's torsion balance and another type of balance in which the lecturer has replaced torsion by electromagnetic control.

It is found that heat treatment causes marked change in susceptibility. The value of this quantity for chalybite is made larger by heating, while in the cases of chrome iron ore and horneblende the opposite effect is produced. Further, the quantitative results of heat

treatment depend upon the state of division and on the access of air. Copper has a negative susceptibility, while its salts show a positive value. Just the opposite is true of magnesium. For more than half a century it has been known that salts with positive susceptibility have a higher value when hydrated than when anhydrous, and this in spite of water's having a negative value itself.

Magnetic separation is now practiced on a large scale. In 1914, 2,200,000 tons of ore were thus dealt with in Norway, in 1917 in Sweden 2,500,000 tons, and in New York 1,200,000 tons in 1916. This is in addition to any separation of wolfram from tinstone ores and of monazite for use in gas mantles.

This subject has a further interest from its relation to magnetic surveys where the susceptibility of rocks has to be reckoned with. When the United States Government was considering a canal through Nicaragua the direction in which the compass pointed on the lake of that name was greatly influenced by the magnetism of a dominating mountain, and in the Boer War the disastrous defeat at Spion Kop was in part due to the confusion of incorrect maps in which directions were modified by the effect of magnetized land masses upon the magnetic needle.

G. F. S.

Sodium Amide.—This compound has been prepared by J. M. McGEE, of the University of California (*Journ. of the Am. Chem. Soc.*, 1921, xliii, 586–591), by the action of anhydrous ammonia on pure metallic sodium in the presence of freshly platinized platinum gauze which served as a catalyst. The amide is a white crystalline solid, melting at 208° C. Metallic platinum catalyzes the decomposition of the amide into sodium imide and sodium nitride; ammonia gas is evolved; and the platinum is dissolved at the same time.

J. S. H.

A comparison of the atomic weights of terrestrial and meteoric nickel has been made by GREGORY P. BAXTER and LEON W. PARSONS, of Harvard University (*Journ. Am. Chem. Soc.*, 1921, xliii, 507–518). The atomic weight was obtained by determination of the ratio of nickelous oxide to metallic nickel. The reduction of the oxide to the metal was carried out in an atmosphere of hydrogen at a temperature of 600° to 900° C. Terrestrial nickel was found to have an atomic weight of 58.70, meteoric nickel an atomic weight of 58.68. This difference lies within the experimental error.

J. S. H.

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